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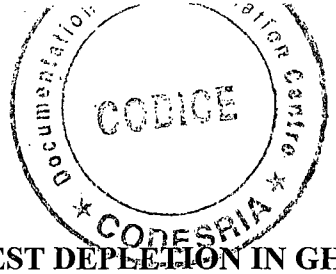
Gold exports and forest depletion in Ghana

JUNE,2003



GOLD EXPORTS AND FOREST DEPLETION IN GHANA

BY

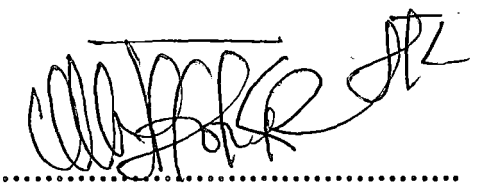
JOSEPH KWADWO TUFFOUR

A THESIS SUBMITTED TO THE DEPARTMENT OF ECONOMICS, UNIVERSITY OF GHANA, LEGON, IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER OF PHILOSOPHY DEGREE IN ECONOMICS

JUNE, 2003

DECLARATION

I, **JOSEPH KWADWO TUFFOUR,** hereby declare that this thesis consists entirely of my own work and that no part of it has been presented for another degree elsewhere.



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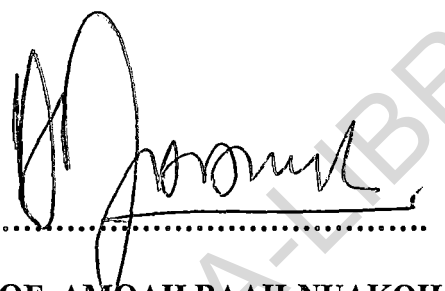

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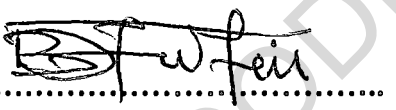

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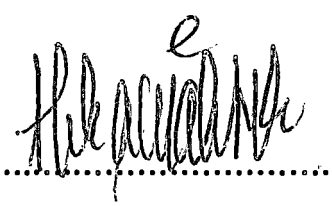

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JUNE, 2003

DEDICATION

I dedicate this thesis to the **Lord Jesus Christ** for giving me the strength to complete this thesis, to my loving mother, **Veronica Akyeamaa,** to my father, **Mr. James Attah** and to my best friend, **Mercy Kyerewa Amfo.**

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I am however, solely responsible for all errors that remain.

JOSEPH KWADWO TUFFOUR

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ABSTRACT

The concept of sustainable development in relation to depletable natural sources such as gold extraction requires thorough consideration. This is due to the intergenerational and intragenerational equity notions that affect mankind. As such, there is the need to maintain such resources on a non-declining basis so as to maintain human welfare over time.

In addition, there is the interdependency between environmental protection and economic growth for which every country strives to attain. In this case, development can take place if and only if there is environmental protection, here relating to gold extraction localities.

This study employs multiple regression concepts to find the relationship between gold extraction for exports and forest depletion. Also, tabular and graphical representation has been used.

The findings of the study indicate that gold extraction for export as pertains to Ghana increases the rate of forest depletion for the study period (1970 – 1997). This suggests that protection of the forest is a necessary and sufficient condition for economic growth and development.

As a result of these, recommendations have been put forward for both government and policy-makers to safeguard the forest estate, by retuning to the formal underground mining and also using part of the returns from gold exports to regenerate the forest.

CHAPTER ONE

INTRODUCTION

1.1: BACKGROUND

Ghana is well endowed with rich natural resources, both renewable and non-renewable such as gold, manganese, diamond, bauxite, silver, clay and timber. Some of these have contributed much to the development of the country for decades; for instance the Obuasi Gold Mine has been in existence for over a century, contributing to Gross Domestic Product (GDP) in the form of employment, revenue and foreign exchange. A large percentage of these resources are exported to other countries.

Mineral production has been on the decline since 1970 when low figures were recorded. For instance in 1970, yearly gold production was 714,442 fine ounces but dropped to 335,754 fine ounces in 1982 (Chamber of Mines Annual Report, 1993). Various factors contributed to such a decline, among them are the lack of maintenance of plants, low level of investment and inadequate infrastructure.

In addition to problems stated above, the Ghanaian economic situation began to worsen at the same time. There was high inflation, souring balance of payments deficits, high budget deficits and over-valuation of the Ghanaian cedi.

This situation necessitated the Economic Recovery Programme (ERP) through the Structural Adjustment Programme (SAP). Several policies were put in place to influence all sectors of the economy including gold mining, exports and the environment.

After this programme, certain economic indicators were restored. Inflation rate declined from 123% in 1983 to 25.2% in 1989. There was also an increase in the real GDP growth rate from - 4.6% in 1983 to 5.1% in 1989 (State of the Ghanaian Economy - ISSER, 1994; Asante, 2000 and Osei, 1995).

The reform in the mining and exports sectors of the economy yielded some benefits. For instance in 1992, gold overtook cocoa as the highest foreign exchange earner (UST/IDRC, 1997 and State of the Ghanaian Economy-ISSER, 1994). Gold contributions to minerals and total exports earnings in 2000 were 92% and 36% respectively.

It is evident that the export of gold and other primary products after the ERP has continued to increase. Unfortunately, increase in production and exports of these products do not affect only present environmental conditions but that of the future as well. These resources are non-renewable or take a longer time to regenerate and to increase their production and export implies more extraction and depletion of the natural resources with their adverse effects.

An activity such as gold mining has varying impacts on the environment. Global environmental consciousness has resulted in greater concerns about the compatibility of the processes with environmental protection (UST/IDRC, 1997 and Ghana Mining Journal, 1996 and 1998). Ghana's Environmental Action Plan (EAP) cites the major

problems associated with gold mining as land devastation, solid waste disposal, soil degradation, water and air quality changes, visual intrusion and alteration of the climate - high temperature and humidity effects.

At the UST/IDRC National Symposium (1997), it was noted that "forest are destroyed as a result of such demanding and immediately rewarding land use options as mining, agriculture, logging, urbanization and bush fires. In general, much of the forest destruction experienced any where in the world has come from human activities in the pursuit of some economic gain for survival".

The choice of gold in relation to forest depletion (for this study) stems from the fact that the main aim of its extraction has been for export. For instance, in 1992 and 1999 total gold production was 999,950 and 2,620,121 fine ounces respectively but the volume exported was 995,377 and 2,550,766 fine ounces respectively. This shows that about 0.45% and 2.64% respectively were used domestically. Since the production and exportation of gold has a significant impact on the environmental, it therefore becomes imperative to study the extent of environmental effects associated with its production and exports.

1.2: STATEMENT OF THE PROBLEM

Ghana's record of mining related environmental issues dates back from the early gold boom in the 1880s and the long supportive timber trade (Ghana Mining Journal, 1996).

The forest and environmental degradation associated with gold mining has been ignored for fear of destroying an industry that has been a major contributor to the national economy for years.

After the reforms in the various sectors of the economy following the ERP, many concessions have been granted for gold mining in order to increase its export and the country's foreign exchange earnings.

It is pertinent that economic development and the environment are interdependent. Sustainable development, that is, maximizing the net benefit of economic development subject to maintaining the quality of the natural resources over time is the ideal situation but it appears that much attention is not given to this, rather the export notion overrides the care for the environment.

It is against this background that efforts to mitigate these effects are necessary in order to reclaim the land back or close to seemingly its original forest state. This paper will examine the extent to which gold extraction for export impacts on the forest of Ghana.

1.3: OBJECTIVES

The study will investigate the expansion of gold exports and its effects on the forest estate under sustainable development in Ghana. In this vein, the specific objectives of the study will include:

1. finding out the extent to which gold exports contribute to forest depletion.
2. examining how gold extraction method influences forest depletion.
3. coming out with policy recommendations to address the forest depletion problem.

1.4: RELEVANCE OF THE STUDY

The demands of growing numbers of people, coupled with the cumulative burden of past over-exploitation, environmental degradation and natural resource depletion will sharply worsen as economies try to develop. This situation is always characterized by the growth and development aspirations of every country. Ghana for instance established the Ghana Export Promotion Council (GEPC) to diversify its export products from the traditional exports like gold, timber and cocoa to focus on the development and promotion of non-traditional export.

Our quest for growth and development with the export led notion has yielded results. Gold exports have been increasing both in earnings and volume. However, its impacts on the forest have also worsened. In the State of the Nation Address 2002, the President of the Republic of Ghana reiterated that "we have lost and are losing on a daily basis, much of our forest through fires, irresponsible utilization and the pressure of population". This

has resulted in a loss from 8.2 million hectares to 1.6 million hectares of the Ghanaian total forest estate in 2002 (Ghanaian Times, 29th January, 2002).

This study aims at finding the extent of gold extraction for export and its effects on the forest of Ghana. Thus, a research as this is relevant in the sense that if gold extraction for export turns up to be significant in contributing to forest depletion, a remedy should be sought. For instance, currently there are both foreign and domestic firms undertaking exploration activities in many of the regions of Ghana. Attention can be shifted to the non-forest areas. This will help curtail the rapid rate at which we are losing the forest.

Again, a study as this will help improve the statistical analysis of the factors determining tropical forest loss. More importantly, insights gained from analysis of tropical deforestation may inform case study analyses of economic behaviour determining land use decisions.

Also, our understanding of the underlying causes and the key processes determining deforestation can be improved. This can in turn support cross-country studies of tropical deforestation.

1.5: HYPOTHESIS TESTING

In the process of examining the issue of gold exports and forest depletion, an empirical testing would be carried out through data analyses. The main hypothesis to be tested is: an increase in gold export increases forest depletion.

1.6: SOURCES OF DATA

Data for the study has been drawn from secondary sources, from the institutions that are directly involved in the extraction and processing of the resource under consideration. The major sources of data and information were:

- Minerals Commission
- Ghana Chamber of Mines
- Ministry of Trade and Industry
- Ghana Export Promotion Council
- Mines Department
- Forestry Commission
- Ghana Statistical Service
- Institute of Statistical, Social and Economic Research and
- Bank of Ghana Annual Reports.

1.7: LIMITATIONS

It is expressed here that carrying out such a research on gold exports with its attendant problems on the forest region of Ghana is beset with limitations. One of the limitations of the study has been the lack of adequate data (time series) to carry out the necessary regression.

Another issue that limited the study was the inability to get data on the extent to which the forest trees are destroyed, such that the total number of trees destroyed cannot be

estimated. Also, an area of inadequate data has been that of bush fires, chain saw operations, urbanization and agricultural clearance.

In addition, the study was limited by the fact that no scientific analyses was undertaken on the effects of the forest depletion, it was limited to social and physical descriptive nature, econometric analysis of the extend and significance of the export product in causing depletion of forest in the areas they are undertaken.

1.8: ORGANISATION OF THE STUDY

This study has been organized into five chapters. Chapter one entails the background, statement of the problem, objectives and its relevance, hypothesis and sources of data. In chapter two, the literature review on gold extraction for exports and its effects on forest depletion in Ghana has been presented.

In chapter three, an overview of gold mining for exports and forest depletion was undertaken. In addition, the importance of gold in exports was considered, as well as Ghana's land under gold mining to find its extent in contributing to forest depletion.

The methodology and empirical data analyses are contained in chapter four. Chapter five contains the findings, recommendations and conclusion on the study.

CHAPTER TWO

LITERATURE REVIEW

2.1: INTRODUCTION

As a matter of fact, forest depletion results from the activities of man in his quest for survival. Many writers and researchers have undertaken the issue of deforestation and export on the global perspective in particular. In addition to this, these analyses have not been quantitative but descriptive on the variables that cause forest depletion. In this section, the literature review on the impact of gold extraction and export on forest depletion has been undertaken.

2.2: BACKGROUND ISSUES

2.2.1: EXPORTS

Every country, regardless of its size, ideology or state of development, participates in international trade. Trade theories have tried to explain why nations trade with each other and how they benefit from it through the "comparative advantage" phenomenon. The implication is that any country can increase her income by trading; the smaller the country, the greater her potential gains from trade. A country will gain most from exporting commodities that it produces using its abundant factors of production more intensively (Gillis *et el.* 1988; Djankor and Hoekman, 1997; MaConnell and Bruce, 1996; Ablor, 1975; Barker, 1997; Jebuni *et el.*, 1994; Ball and McCulloch, 1996 and Lipsey 1993).

Ghana, even though small in size relatively, is well endowed with rich natural resources both renewable and non-renewable. For instance, gold and timber have been in use for over a century while others like manganese, diamond, bauxite, silver, clay are not well exploited. These have contributed much to the development of the country for decades, in the form of employment, revenue to the government, foreign exchange and infrastructure provision.

According to Buame (1998) and Tawia (1998), the benefits of outward orientation can well be seen; it leads to better allocation of resources, increased capacity utilization and economies of scale. This can also contribute to economic growth by lowering the trade deficit, creating jobs, enhancing business opportunities, encouraging technological development and enlarging the market base of the commodities involved.

Ghana's economy is becoming more export oriented as its export position has increased steadily over the years. For instance, in 1990 total export earnings which was US$ 896.76 million, increased to US$ 2,005.5 million in 1999, representing about 55.2% increase. This situation has been going on under globalization and trade liberalization concepts and policies.

The Bruntdland Commission's view is that world primary commodity trade frequently encourages resource depletion in the developing world (Pearce and Warford, 1993). The Bruntdland Commission argues, "the promotion of increased volume of commodity exports has led to cases of unsustainable overuse of the natural resource base. While

individual cases may not fit this generalization, it has been argued that such processes have been at work in ranching for beef, fishing in both coastal and deep sea waters, forestry and the growing of some cash crops. Moreover, the prices of commodity exports do not fully reflect the environmental cost to the resource base" (World Commission on Environment and Development, 1987:80-88 and Pearce *et el.*, 1991).

If however, the earnings from the exports are converted into other forms of capital investment, proper user cost adopted, and their prices reflected in the appropriate social cost, then trade in these non-renewable resources presents less of a problem. But trade products which are often environmentally devastating when produced on cleared forest such as gold tend to suffer from price variability and falling per unit price of exports relative to import price (that is the commodity terms of trade).

According to Nkrumah (1997), the country has adopted an outward strategy as part of the economic development process. This is expected to lead to increases in the performance of the export sector. Of course, this strategy can be taken from different perspectives; the free trade route that entails trade liberalization or from the active governmental intervention arena where export subsidy and other packages are put in place.

The view of conventional economic thinking on the matter is obvious, that governmental intervention in the allocation of resources of a nation leads to inefficient allocation of resources; however, this view has been refuted. South Korea, contrary to the conventional view tends to support governmental intervention in export promotion. This was part of

her initial development strategy, export subsidy notion was stronger than free trade. Looking at the policies put in place after the ERP, one tends to accept that, Ghana has implemented both the free trade and governmental intervention strategies.

On the whole, the ERP tackled various sectors of the economy. The export-related policies outlined in the government's guidelines for promoting exports included the following:

- Restructuring of institutions dealing with exports,
- Ensuring that credit requirements of export sector were adequately met,
- Simplifying procedures related to exports,
- Increasing flexibility of the use of export retention accounts, reviewing existing schemes and evolving new ones (Sey, 1997).

Of course, these policies were not put in place just for the sake of it but to address specific problems that existed in both the Traditional Sector (TS) and the Non-Traditional Sector (NTS). However, much emphasis was placed on the NTS to supplement the efforts of the TS. This was because at the early stages of the ERP, the NTS was not performing at its best. Some of the problems were the difficulty in accessing credit facilities, the development and production of good quality products, marketing of their products to the international buyers and the cumbersome shipping procedures.

Gold and other primary products are extracted from the forest region of Ghana. This suggests that forests are valuable and must be conserved as we pursue development.

2.3: THE IMPORTANCE OF TROPICAL FOREST

The issues of environment and development have taken an increasingly important place on the international agenda since the Stockholm Conference in 1972. In the past, environmental degradation was viewed as a problem of industrialized nations alone, but now it has been recognized to be a vital issue in developing countries as well, in view of the new, intensive growth and development agenda (United Nations Department of Technical Cooperation for Development, 1992). As of now, there is a general agreement on the importance of safeguarding the natural environment and on the necessity of achieving sustainable development as we pursue our survival and development goal.

Economic development and environmental protection are interdependent, in this situation, the idea of sustainable development becomes apparent. In an attempt to maximize the net benefit of economic development today, we must ensure that the quality of the natural resources are not underestimated so as to leave the resources in a better condition to support future generations. This is the ideal situation but it appears that much attention is not given to this. Rather the export notion overrides care for the environment. Since major components of our export products (gold, cocoa and timber) are obtained from the forest region of Ghana, to earn foreign exchange to harness her developmental process and cause economic growth, its effects on the forest cannot be over looked.

The protection of the environment is an essential part of development. Without adequate environmental protection, development will be undermined and without development, resources will be inadequate. In this case, it can be said that development can take place

if and only if there is environmental protection. This presents trade-offs and choices which policy–makers have to make, since there are many development objectives and strategies pursued by countries, so are there many legitimate debates within the environmental circle about ways to value and manage the environment (Brandon and Brandon, 1992).

By 1989, the area covered by moist tropical forest worldwide was less than 60 percent of the original extent of 13.6 million kilometers (Myers, 1982). According to Gillis *et el.* (1988) and Repetto and Holmes (1983), this means that an area of forest cover larger than the Soviet Union has disappeared primarily since 1945. The accelerating loss of tropical forest cover involves economic, ecological and equity issues which are of prime importance to growth and development.

Deforestation is defined as the permanent conversion of forestland to other uses, including pasture, mechanized agriculture, shifting cultivation, exploitation of other natural resources like minerals and crude oil, infrastructure development or commercial logging. These changes in the forest crown from closed to open forest, negatively affect the stand, site, and lower the productive capacity of the forest.

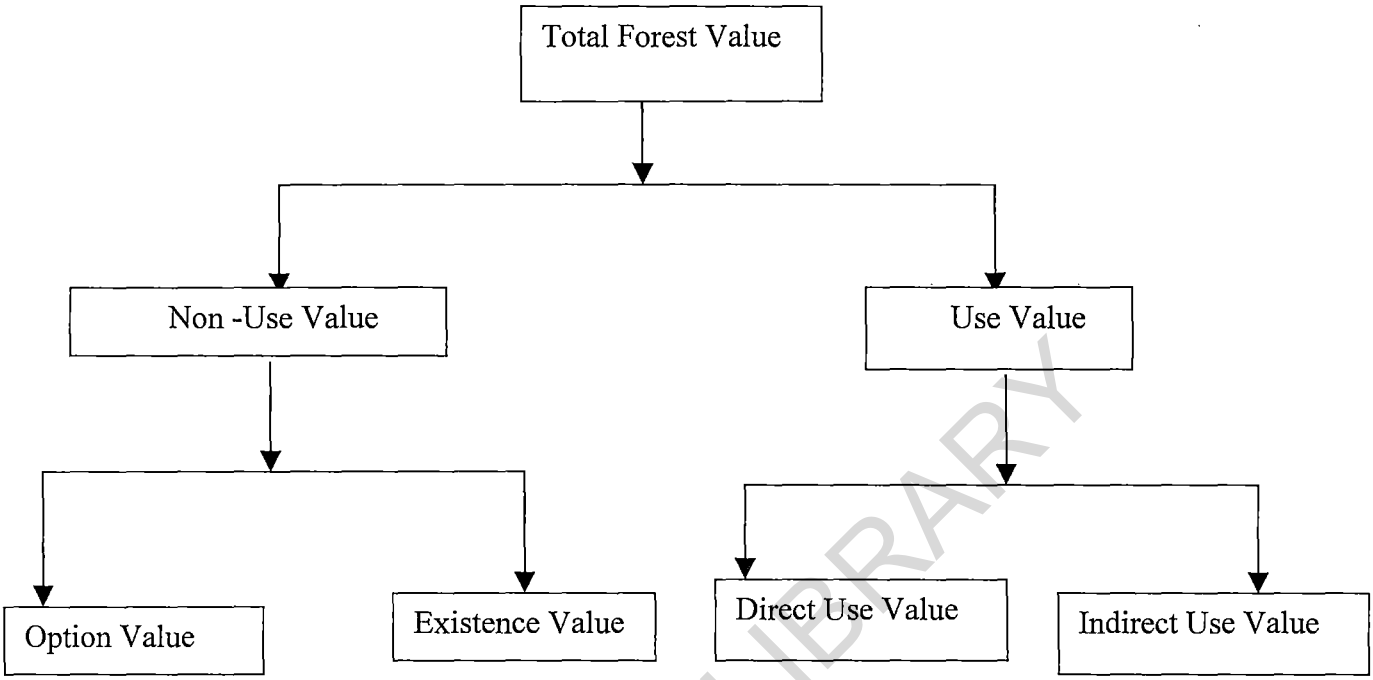
Stern *et el.* (1996), propose that there is an inverted U-shape relationship between environmental degradation and income per capita so that eventually, growth reduces the environmental impact of economic activity. This, to some extent supports the interdependency of economic development and environmental protection stated above.

But this concept is dependent on the model of the economy in which there is no feedback from the quality of the environment to production possibilities and in which trade has a neutral effect on environmental degradation. This paper examines implicitly the alternative where trade product (gold) is taken into consideration to ascertain the variation or conformity of the above assertion.

In spite of the interdependency of development and environmental degradation, the forest offers mankind a wide range of benefits. There are various land use options for tropical forest. They can be left alone, if no human use is permitted at all. This outright prohibition can be termed as Preservation. On the other hand, allowing human use of the forest on sustainable bases can be defined as Conservation. Pearce (1991) argues that any use option that produces irreversible effects is not a conservation use of the land.

The total value of tropical forest can be expressed as being the sum of direct use and indirect use values (both forming the Use Value) and option and existence values - Non-Use Value (Pearce, 1991; Ehrlich and Ehrlich, 1992; Tutu, 1992 and Smith, 1997).

Figure 2.1: The value of tropical forest



The focus on tropical forests has of late came up due to the needed diversity of functions which they serve, the uniqueness of primary forests in ecological terms and accelerating threat to their existence.

One of the direct use values of forests is the supply of hard wood timber. In the 1980s, Ghana's timber harvest was less than 1 million cubic metres per year, this value increased to about 1.8 million cubic metres per year in 1994. Although, the Annual Allowable Cut (AAC) or sustainable level of cut has been fixed at 1 million cubic metres in Ghana, the

figures have always been exceeded. This anomaly was due to factors such as illegal felling, inadequate control and enforcement of the sustainable forestry management laws.

Again, the forest provides plants, herbs and roots, which are used for medicinal purposes. The forest supplies other products such as fruits, nuts, latex, rattans, meat, honey, resins and oils among others

Indirectly, forest provides habitat for extensive fauna and flora (biodiversity – the variety of genetically distinct populations and species of plants, animals and microorganisms with which homo sapiens shares earth and the variety of ecosystems of which they are functioning parts), which are valued for educational purposes and for crop-breeding purposes. It also provides a recreational facility ("ecotourism"), which serves as a source of revenue.

Forest also protects watersheds in terms of water retention, flow regulation, water pollution and organic nutrients cleansing and recycling, Again, it fixes carbon in secondary forests and in reforested areas, and acts as no net gain in the flow of carbon dioxide.

Option value relates to the amount that individuals would be willing to pay to conserve the tropical forest for future use. That is, no use is made of it now, but it is reserved for the future. Option value is thus like an insurance premium to insure uncertainty in the supply of the natural resources. While there can be no presumption that option value is

positive, it is likely to be so in the current context of valuation (Barbier, Burgess and Markandya, 1991).

Existence value relates to valuation of environmental asset unrelated either to current or optional use. Its intuitive basis is that, a great many people reveal their willingness to pay for the existence of environmental assets through wildlife and other environmental charities (Ehrlich and Ehrlich, 1992; Sharma *et el.,* 1992; Pearce, 1991 and UST/IDRC, 1997).

Since Ghana is endowed with several natural resources like gold both on and under the land, it presupposes that these resources should be tapped for development and this leads to a reduction of the forest size.

2.4: CAUSES AND EFFECTS OF FOREST DEPLETION

The fate of the tropical forest is now an important issue of major concern to the world at large. This is due to the fact that the usage of the forest is quite unsustainable in the sense that the rate of depletion is far greater than that of tree planting and regeneration in most countries especially Ghana.

Ghana's record of environmental issues related to gold mining dates back from the early gold boom in the 1890s and the long supportive gold trade (Ghana Mining Journal, 1996). The forest and environmental degradation associated with gold mining has been

looked on for fear of destroying the industry that has been the major contributor to the national economy for years.

After the reforms in this sector that followed the ERP, many concessions were granted for gold mining, (for export to earn the country foreign exchange for development). This has resulted in gold export earnings overtaking cocoa in 1992 as the number one foreign exchange earner (ISSER, 1994).

Oteng-Yeboah (1997), argues that since mining (surface mining) activities temper with the forest region, it is quite appropriate to examine ways in which the effects can be mitigated. A general review on the forest estate including the soil is necessary to set an illustration and discussion. He, like Tufuor (1997) identifies the major causes of deforestation in Ghana to be agriculture, logging, mining and urbanization.

The spread of deforestation is positively related to development option of the land use especially near communities (Anderson, 1987; Perez-Garcia and Lippke, 1993; Blomqvist and Davies, 1974 and Gillis *et el.,* 1988). The growth of towns and cities brings about appreciable demand for fuelwood and decline in tree stock, in rural areas (World Bank, 1987). Investments in road building, hydroelectric projects and housing, necessary to meet the development objective in a country like Ghana are beset with environmental trade-off. Infrastructure projects undertaken in the forest region without adequate impact assessment lead to forest depletion.

According to Tufuor (1998), the prime source of energy in Ghana is from biomass, firewood and charcoal, which accounts for about 78% of the total energy consumed in the country. This figure is likely to upsurge with the increase in population. The major areas that use the abundant firewood have been the rural areas. In Ghana, in 1983, it was estimated that for every tree harvested for lumber, nine were cut down for firewood.

Since central governments in many developing countries are unable to enforce forestry laws and regulations in remote areas, the local people have often been powerless to resist opening access to the forest leading to uncontrollable exploitation. Thus, the forest becomes an open access or common property resource. This has become what is known as "tragedy of the commons" especially for the communities that live around the boundaries of the forest regions (Hadin, 1968; Harkwick, 1992 and Wade, 1987).

Another area that is seen to contribute immensely to forest depletion is the external factor – demand of foreign countries for timber and timber products from developing countries in the tropics. For instance, the export volume of timber in 1990 was 370 thousand M^3, which increased to 780 thousand M^3 in 1999 the highest in the 1990s. In Ghana this has been one of the main areas that causes deforestation as current levels of extraction in tropical forest exceeds the rate of reforestation (Barbier and Rauscher, 1994). Traditionally, natural forest management has been regarded as loss making unless biological growth rates are very high, stumpage prices (log prices) are high, management is effective and at minimum cost and the discount rate is low compared to typical

commercial and even official government levels (Pearce, 1991:4; UNDP, 1992 and UN, 1992).

Annually, 3 to 4 million hectares of commercially productive closed forest are logged worldwide (Food and Agriculture Organization - FAO, 1992). There is some regional variation in the relative contribution of commercial logging to loss of tropical closed forest. In Africa, about 20% of the productive tropical forest was logged by 1985, whereas in Asia and Latin America, the figures were 19% and 9% respectively (Rowe *et el.*, 1992).

Subsistence farming activities in developing countries account for nearly 60% of the loss of the tropical forest annually, even though regional variations are substantial. According to FAO (1982), shifting cultivation was the leading cause of deforestation in both tropical West Africa and Semi-arid Africa, accounting for 70% of the woodland, even though shifting cultivation has the indirect inherent ability to allow the land to retain its fertility (fallow period). Currently, this method does not and cannot be adequately adhered to because of population increase. The pressure from population explosion does not allow the land to 'rest' enough or it is no longer given any fallow period at all bringing more land under cultivation. The end result is that, the land losses its fertility and cannot retain its forest status again.

It is an undeniable fact that, the rate of deforestation is hastened by the rate of population growth. Population growth, coupled with other factors such as inappropriate technologies

and inadequate development policies have given rise to a pronounced over-exploitation of the natural resource stock. This leads to numerous environmental discontinuities, whereby the self-sustaining equilibrium is suddenly and radically brought to an abrupt end (Myers, 1992). The spread of deforestation is noticeable near urban areas. The growth of towns and cities according to Anderson (1987) leads to the observed decline in tree stock in the surrounding countryside. The need for housing, roads and other infrastructure, food and fuelwood all come from the pressure imposed by population increases. In countries with high population densities such as Bangladesh, El Salvador, Haiti and Nepal, deforestation is definitively linked to population growth (Rowe *et el.*, 1992:40).

Population growth has also contributed to forest depletion in Ghana. In the early 1900s, it was estimated that Ghana had over 8.3 million hectares of forested land when the population was less than 3 million. There was forest depletion of 78% by 1980 when the population had risen to 12 million.

Barbier, Burgess and Markandya (1991) sided strongly with Rowe *et el.* (1992) that policy failure contributes to forest depletion in countries where forests are found. Many tropical forests are undervalued by those responsible for their management and use. In addition, governments are often found to support such tendencies by employing misguided policies and sanctioning inappropriate resource rights to forests. The economic factors influencing deforestation in countries with tropical forest includes prices and economic incentives that do not reflect the total cost of deforestation. This can happen in

two ways, first the value of tropical timber products or products derived from converted forestland do not incorporate any environmental costs, option and existence values. Second, the direct costs of harvesting timber products and converting tropical forests are most at times subsidized.

Mining activities in Ghana have been on the increase since the first gold boom in 1892 especially for gold (Dzigbodi-Adjuma, 1996). The increase in export of products such as gold, and other primary export products stem from the fact that there are 'abundant' stocks (Ghana Mining Journal, 1996). Almost gold trade has been the mainstay of the export earnings of the country especially in the 1990s. For instance, after the first gold boom was started in 1892, there has been gold mining in areas like Obuasi, Prestea, Konongo, Abosso and Tarkwa.

In collaboration, logging is also carried out in the same area (forest area), and the combined operations yearly reduce the forest estate of Ghana. Apart from exporting logs as pertained in the period before logs exports were banned, timber was felled and used for mining purposes.

Even though, the above causes of forest depletion cut across different regions of the world, Tufuor (1997) argues that there are several causes of forest depletion in Ghana; clearing for unsustainable shifting cultivation, the need for fuel wood and charcoal, about 78% of household energy demands in both rural and urban areas are met through fuel

wood. Commercial tree felling effects, bush fires, urban expansion and mineral extraction are among other causes of forest depletion.

These causes without doubt, have varying impacts on society. Many people in developing countries live in villages that depend entirely on the water provided by watersheds contained in the forest. The loss of forest can impede the functions of watershed causing downstream effects for users. This has been the main cause of the hydroelectric power shortage that occurred in Ghana in 1998.

Rowe *et el.* (1992), argue that although tropical moist forest cover only 9% of the earth's land surface, they are the main source of biodiversity. It is estimated that about 1.4 million named species are contained in them.

The notion of 'Encroaching Sahara' has also been one of the major concerns of forest depletion. This is seen mostly at the upper boundaries of the forest regions where gradually grassland is replacing previously forest estate.

Angelsen and Kaimowitz (1999) argue that the loss of forest cover influences the climate and contributes to the loss of biodiversity as also stated by Rowe *et el.* (1992), Ehrlich and Ehrlich (1992), Dasgupta and Moler (1990), Barbier and Rauscher (1994). Forests help to regulate the atmospheric temperature through absorption of carbon dioxide and other gases. Other consequences have been reducing timber supplies, siltation of river

courses, flooding and soil degradation affecting both economic and social activities by treating the livelihood of forest dependent people in particular.

From the reviews above, various writers have considered forest depletion by examining the various causes including mining. However, these studies have always been descriptive in nature and focus on the factors that cause forest depletion in Ghana. There is the need to statistically estimate the extent to which these factors contribute to forest loss.

Again, those studies that touched on mining did not consider the individual minerals that are mined in the country but rather aggregated the minerals and examined the combined effects. It is therefore important to consider gold in particular, which is the well mined mineral to find its extent in contributing to forest loss in Ghana. This is because, each of the other major minerals mined (bauxite, manganese and diamond), has one major operating company unlike gold. Thus, gold has to be examined critically.

Moreover, the previous studies considered the extraction of products some of which are exported. This study examines the extent to which foreign demand in particular adds to the loss of forest in developing countries such as Ghana. Gold has been the major export earner over the last decade. Exporting gold leads to forest depletion through the method of extraction.

2.5: GOLD MINING METHODS AND ENVIRONMENTAL EFFECTS

As can be seen from Figure 2.1, the part of the country that contains forests is the southwestern area, in this same location, all the gold mining operations take place. There are two main ways of undertaking these activities, through underground and surface mining.

In underground mining, shafts are made deep into the ground to reach the orebody. The ore is then drilled and conveyed to the surface, and then goes through the milling process.

The underground method indirectly causes forest depletion through the use of wood for construction purposes and also where the tailings are dumped thereby destroying the vegetation. This method was usually used in the period before the ERP.

The new mining initiatives, which came into being after the ERP, had seen new mining methods - highly mechanized surface mining technologies unlike the previous underground method. This is where everything on the surface of the land is cleared to make way for the ore. It is coincidental that, the well-known high-grade gold areas are in the forest region. This outright clearing renders the forest totally eradicated from such gold mining concessions. As a matter of fact, to increase production means using more land and hence more forests estates are destroyed.

In the case of surface mining, the nature of the environmental problems of gold mining can be traced from the method of operation through exploration to fabrication. The blasting - a method of breaking the hard ore bearing rock (mineralized zone) also causes a lot of environmental disturbances: these range from noise pollution, air pollution (emission of dust and smoke from excavation and transportation of the ore waste), to vibration which causes cracks in the buildings of near-by settlements.

After the blasting, the ore is scooped and hauled through trucks or conveyer belts for grinding. Gold, which is the most widely produced mineral in Ghana is extracted in many ways: Heap Leach (HL), Carbon-in-Pulp (CIP) and Carbon-in-Leach (CIL). The Heap leach – is a technique for extracting metals from ore by percolating (leaching) a cyanide solution through heaps of ore placed on impervious pads or base pads.

The Carbon-in-Pulp is a process used to recover dissolved gold from cyanide slurry. Coarse activated carbon particles are moved counter-current to the slurry, absorbing the gold as it passes through the circuit. Loaded carbon is removed from the slurry by screening. The gold is recovered from the loaded carbon by stripping in a caustic cyanide solution followed by electrolysis or zinc precipitation (Ashanti Goldfields Limited Annual Report, 1999 and Acquah, 1992).

Carbon-in-Leach process is a modified CIP whereby carbon is added directly into the slurry during leaching as opposed to CIP where carbon is added after leaching is complete.

The tailings (waste materials from ore after the economically recoverable metals or minerals have been extracted) cause health problems like tuberculosis when the fine particle mixes with the air (Tufuor, 1997 and Asamoah, 1998).

The methods above use cyanide acid, which is poisonous and dangerous to any living thing, both plants (forest) and animals, thereby affects the underground water table and aquifer, and also interferes with the atmospheric resources.

The scooping of the ore-body through to crushing, as well as mining with other chemical kills any organism living in or on the land. These activities reduce wildlife production since the noise from blasting and continual working of machines send wildlife away from their dwelling place. The existence of wildlife and human beings is threatened by any spillage from the mines, as it occurred in Akyempem and Tarkwa in October 2001 by Goldfields (Gh) Limited and Satellite Goldfields Limited (Daily Graphic, Friday November 16, 2001 and The Independent, October 22, 2001).

In areas where the surface mining method is used, almost all drainage systems are completely destroyed. Also, the underground water aquifer is sometimes tampered with by the way the pits of the mines are created. The underground water is pumped out to the ground. This water if not used, causes flooding in other low-lying areas and also reduces the quality and quantity of water available to the communities in their wells and bore holes during the dry season.

Surface mining does not co-exist with anything and thereby any vegetation is completely cleared, whether forest or bushes. The land is laid completely bare making it susceptible to all forms of erosion. Since the large pits created by the mining operations are not filled after mining, it follows that, the area cannot retain its vegetation again but at best is filled with water, which has its side effect of breeding mosquitoes for the communities.

From the ongoing discussion in this chapter, it follows that economic activities such as gold mining, agriculture, fuelwood gathering, commercial logging, bush fires, charcoal burning, chain saw operations and infrastructure development are perceived as direct causes of deforestation. On the other hand, economic, social and political forces in an economy drive these factors such that they manifest or reveal their impact through market and policy failures, population and poverty pressures, which differ in strength among countries.

CHAPTER THREE

OVERVIEW OF GOLD EXPORTS AND FOREST DEPLETION IN GHANA

3.1: STATE OF THE GHANAIAN ECONOMY BEFORE AND AFTER THE ECONOMIC RECOVERY PROGRAMME (ERP)

The Ghanaian economy suffered a protracted decline in the three decades following independence in March 1957; this was mainly in the 1970s and 1980s. The growth of output averaged 2.2% between 1960 and 1970 but fell at a rate of 0.5% after 1970 (Sowa and Kwakye, 1993; Baah-Nuakoh, 1997 and Asante, 2000). For instance, the lowest recorded growth rate was in 1975 where the rate was -12.43%. This was due to a catalogue of factors such as poor weather conditions, inadequate marketing and distribution networking, poor storage facilities, low productivity, fast-growing population, urbanization and inappropriate pricing policies aimed at keeping prices down. As a result of these, the medium-income status of Ghana moved to a low-income country by latter years of 1970s.

The export sector was not spared either. The export sector index dropped from 154.7 in 1970 to 58.8 in 1983 (1975 = 100). As exports declined, import substitution industrialization effort was pursued to reverse the declining income per capita, mounting external deficit, high inflation rates, economic stagnation, shortage of food and dilapidated state of social and economic infrastructure. The only export products that contributed much to foreign exchange were gold, cocoa and logs.

Economic controls and restrictions from 1972 until early 1983 led to a number of malpractices including smuggling, 'black market' activities in goods and foreign currencies, corruption and cheating. As a result, inflation rate for the first time after independence recorded a 3-digit figure of 123% in 1983 as shown in Table 3.1 below (page 33).

Due to the over-valuation of the cedi and instability of cocoa earnings, foreign exchange was scarce. This severe scarcity constrained the ability to supply essential imports for consumption and also for the manufacturing sector.

The government intervention in the economy as well as massive expansion of the public sector through establishment of a large number of state own enterprises worsened incentive to produce, save and invest. There was much unemployment, and under-employment was high.

The balance of payments (BOP) was in continuous deficit from 1976 to 1983 except for 1979 when the BOP registered a surplus of US $ 69.8 million. There was also large budgetary deficit mostly financed by increases in money supply (Osei, 1995 and Fosu, 1992). By 1983, the economy had sunk to the lowest level ever in history. The drought and bush fires aggravated this situation in 1975 - 1977 and 1981 - 1983. The external factors that contributed to the deterioration of the economy were the sharp increase in petroleum prices and deterioration of the commodity terms of trade.

In an effort to save the situation as stated above, the then Provisional National Defense Council (PNDC) government launched the Structural Adjustment Programme (SAP) popularly known as Economic Recovery Programme (ERP) in mid-1983. The International Monetary Fund (IMF) and the World Bank (WB) sponsored this programme. Its aim was to reverse the decline of the economy.

The main purpose of the programme was to revamp the economy - reduce structural imbalances and establish a path of sustainable growth. It was aimed at reversing these economic declines by giving more room to the private sector to operate, improve public and financial sectors and strengthen the productive sectors.

To this end, far-reaching measures and reforms have been implemented over the years. These include price de-regulation, trade liberalization, exchange rate regime changes (moving from a fixed rate system since independence in 1957 with occasional devaluation to the present flexible, market determined – interbank and forex bureau system), financial sector reforms, and rehabilitation of economic and social infrastructure. Also, there have been efforts to maintain a favorable balance of payments position, withdrawal of subsidies and budgetary restraints by cuts in government expenditure.

The programme was divided into two phases, the initial three-year stabilization phase (1983 - 1986) and the subsequent years of adjustment and growth. After this programme, certain economic indicators were restored such as inflation rate declining from 123% to a

low level of 12.5% in 2000, over-valuation of the cedi at 2.75 per US dollar was devalued and later allowed to be flexible by allowing demand and supply conditions to operate to fix the exchange rate. There was an increase in economic growth from -4.33% in 1983 to 3.7% in 2000 (Table 3.1). The policies also have had several impacts on the economy including that of exports and forests.

Table 3.1: Some economic indicators of Ghana (1970 – 2000)

Year	GDP growth (%)	BOP (US Mil $)	Inflation rate (%)	Interest rate (%)	Exchange rate (¢/$)
1970	9.8	2.5	3.0	5.5	1.02
1971	5.2	5.5	8.8	8.0	1.03
1972	-2.5	63.3	10.7	8.0	1.32
1973	2.9	70.7	17.0	6.0	1.16
1974	6.9	-91.1	18.7	6.0	1.15
1975	-12.4	106.3	24.5	8.0	1.15
1976	3.5	-137.3	62.1	8.0	1.15
1977	2.3	-8.4	116.5	8.0	1.15
1978	8.5	-62.4	73.1	13.5	1.51
1979	-7.8	69.8	54.4	13.5	2.75
1980	6.2	-1.3	50.1	13.5	2.75
1981	-3.5	-288.3	116.5	19.5	2.75
1982	-6.9	-17.9	22.3	10.5	2.75
1983	-4.6	-180.9	122.8	14.5	3.45
1984	8.6	35.6	39.6	18.0	35.34
1985	5.1	14.1	10.4	18.5	54.05
1986	5.2	-60.8	24.6	20.5	89.29
1987	4.8	140.1	39.8	23.5	147.06
1988	5.6	181.1	31.4	26.0	200.00
1989	5.1	156.6	25.2	26.0	270.27
1990	3.3	105.9	37.2	33	326.33
1991	5.3	136.7	18.0	20	367.83
1992	3.9	-122.8	10.1	30	437.09
1993	5.0	53.3	25.0	35	649.06
1994	3.8	172.1	24.9	33	956.71
1995	4.5	250.8	27.9	45	1200.43
1996	5.2	-20.4	46.6	45	1637.23
1997	4.2	26.7	27.9	45	2050.17

1998	4.6	107.8	15.7	37	2314.15
1999	4.4	-47.9	13.8	27	2647.32
2000	3.7	-258.5	12.5	27	7142.86

Source: AERC Research Papers 22, 37 and 100 and International Financial Statistics 2001 Year Book

3.2: OVERVIEW OF REFORMS IN THE EXPORTS SECTOR IN GHANA

The country experienced BOP deficits for several years until the ERP. In 1974, BOP deficit was US $ -91.1 million, but it worsened to US $ -288.3 million in 1981. This was due to excess demand over supply of tradable goods. There were deteriorating terms of trade, scarcity of foreign exchange to import raw materials and replace obsolete machines.

The ERP was pivoted on "export-led growth strategy" as one of the wheels of growth. It had strategies adopted and designed to resuscitate the traditional export sector and support systems required to make them operationally active to contribute to GDP and foreign exchange supply. This notion (export-led growth) brought reforms to enhance the traditional export products as well as establish the Ghana Export Promotion Council (GEPC) to promote exports from non-traditional sector.

Other reforms in the export sector were the removal of price controls, exchange controls, import licensing problems and devaluation of the cedi. The composition of Ghana's export is still concentrated in gold in particular, timber and cocoa. For instance, gold

alone accounted for 45.2% of the value of merchandise exports earnings in 1994 (ISSER, 1994).

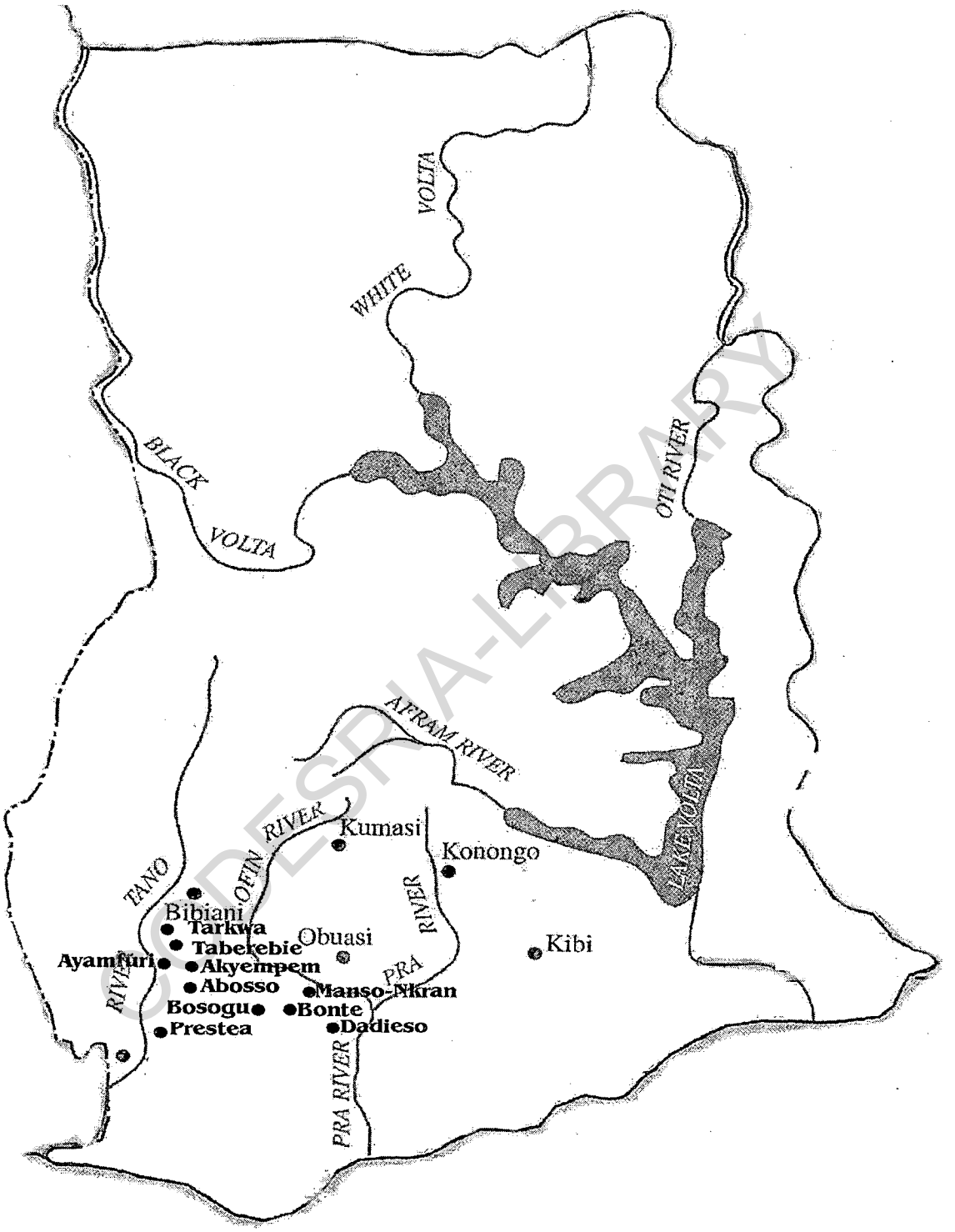
3.3: PRE – AND POST ERP OF GOLD MINING IN GHANA

Ghana is well endowed with substantial mineral resources. The predominant among these resources are gold, diamond, manganese and bauxite. The dominant mineral produced and exported - gold accounts for about 90% of all mineral revenues (Bank of Ghana data). This high proportion of mineral export is due to the fact that gold is found in many parts of the country, and has also received much of the investment after the ERP. The gold belts are mainly found in the:

1. Birimian rocks with their associate granitoids
2. The Tarkwaian rocks
3. Alluvial derivatives of the Birimian and Tarkwain rocks
4. Gold mine dumps and mill tailings (UST/IDRC, 1997).

The first gold boom that started around 1892 was disrupted in 1901 by the Yaa Asantiwa War and finally ended with the outbreak of the First World War in 1914. This period marked the start of mining activities at the current well-known gold mining areas such as Obuasi, Konongo, Tarkwa, Abosso and Prestea (as seen from Figure 3.1 below). The second boom began in 1925 with rehabilitation of many of the mines that were started during the first boom but this was also brought to an end by the close of the Second World War in 1935 (Ghana Mining Journal, 1996).

Figure 3.1: Some current gold mining areas in Ghana



Gold production increased steadily to a peak of 951,316 ounces in 1960 as more gold mines were established. Production afterwards began to fall in the later part of 1970s to early 1980s and by 1983, the total volume of gold ounces produced was 285,291 (Minerals Commission).

The decline in output was due to several factors such as the pull out of multinational companies during the country's move to self-government from 1948 to 1957. Another contributing factor was the socialist ideas and policies that were initiated after independence from the British rule. These policies were conceived to be hostile and uncooperative to foreign investment. The State Gold Mining Corporation (SGMC) was established to take over and revitalized all gold mines abandoned by the foreign firms in 1960. By 1972, operating mining companies were decreed by the NRCD Law 132 to be re-organized as Ghanaian companies and a 55% equity shares in all mining ventures in Ghana (Ghana Mining Journal, 1996:22 and UST/IDRC, 1997:11).

Other problems of the gold mining industry were:

- General macroeconomic problems such as inflation, various price controls, shortage of foreign exchange, bureaucratic and cumbersome import licensing procedures.
- Lack of a clearly defined Mineral Policy in terms of an appropraite legal and institutional framework.
- Deterioration of infrastructure and facilities such as roads, railways, ports and electricity.
- The issuing of mineral rights was characterized by red-tapism.

The third gold boom of Ghana started in 1986 with the introduction of new and friendly investor policies. The main policy objective for the mining sector was, in the short run, reversing the decline in production by initiating measures for helping existing mines to rehabilitate, acquiring of equipment and machinery, up-grading mines infrastructure as well as putting more dynamism in the management of the mines.

After these reforms, almost all the State–owned gold mines have been divested or privatized. In 1999, 25% of the shares of Ashanti Goldfields went public with eleven other new mines opening with private funding and involvement. In addition to the new Minerals and Mining Law (PNDCL 153) promulgated in 1986, the Minerals Commission was initiated to provide a flexible mineral right and mining lease licensing for potential investors and to strengthen existing ones. Another long-term objective was to attract investors into exploration for gold and other untapped minerals.

The policies yielded results by way of reversing the declining trend in production especially for gold. From a low level of 233,042 ounces produced in 1981, the production increased to 2,620,121 ounces representing an increase of about 87% in 1999.

After the reforms were made, several companies were granted gold mining leases. Between 1986 and 1991, six of these companies started producing. These were: the Obenemase Gold Mines (formally the Southern Cross Mining Limited) near Konongo, Teberebie Goldfields near Tarkwa and Ghana Australian Gold also near Tarkwa which are now non-operational, Billiton Bogosu Gold at Chujah near Bogosu, Goldenrae

Mining Company at Kwabeng and Bonte Gold Mines near Kumasi. Other new gold mines were operational since 1995 including Abosso Goldfields Limited, Prestea Sankofa Mining at Preastea, Cluff Mining (Gh) Limited at Ayanfuri, Barnex Gold at Prestea, Midras Mining Company at Danato, Satellite Goldfields Limited at Akyempem, Resolute Amansie Limited at Manso-Nkran and Goldfields (Gh) limited at Tarkwa.

This development would not have occurred without specific measures and policies put in place in the mining sector of which the gold sub-sector had received much of the impact.

3.4: POLICIES INITIATED IN THE MINING SECTOR

Due to its enormous contribution to economic development and its potential for enormous gain, the mining sector was one of the sectors of the economy that much recognition was given to when the ERP was initiated. For this sector to be able to achieve this objective, it was necessary that certain measures, policies and institutions be put in place in order to eliminate the then existing difficulties of the mining sector especially with respect to gold. Some of the problems were obsolescent machines and equipment, import licensing problems, scarcity of foreign exchange, mining licensing acquisition problems, lack of mineral policy in terms of an appropraite legal and institutional framework and deteriorating infrastructure.

The reforms were mainly instituted to address the declining output which reflected in total export of minerals and gold in particular, which invariably affected the balance of payments and its attended problems on the economy. In this regard, a new mineral policy, new financial provision, mining legislation, establishing new institutions and strengthening existing ones that deal with mining in the country were put in place.

3.4.1: GHANA'S MINING AND ENVIRONMENTAL GUIDELINES

Evidence from mining operation in the country reveals that all active gold mining activities are taking place in the forest region of Ghana. Although there are certain operations in the northern part of the country, those are recognized as small-scale un-mechanized type. As can be seen from Figure 3.1, all the active mining operations are taking place in Ashanti, Western, Eastern and Central Regions; the country's major forests are also located in these areas.

The main reason for the concentration of mines especially for gold in the forest area is due to the fact that the gold bearing rock (belt) is located in these areas. At present, there are exploration activities for gold in Brong Ahafo Region in addition to the regions that already have mining operations. These locations can be seen from Figure 3.1. Currently, mining operations for the four major minerals (gold, manganese, bauxite and diamond) are all of Open Cast or Surface Mining technology. This is where both the scooping and hauling of the soil and tailings (soil that a mineral has been extracted from) render the land incapacitated for use, for several years if proper reclamation practice is not adhered to.

As a result of this phenomenon (Surface Mining technology), and its effect on the environment, various institutions that are responsible for maintaining the environment have instituted several policies, measures and guidelines such as Environmental Impact Assessment (EIA) to safeguard the environment's maintenance, regeneration and conservation.

In order to maintain, sustain and build on its contribution to the developmental process of Ghana, the mining industry particularly gold is taking active procedures to address the forest depletion problem as the economy moves along the path of economic development. Since 1989, it has been the requirement in Ghana to subject all major developmental projects to Environmental Impact Assessment (EIA). In Ghana, mining projects, which cover a concessional area of about 25 acres, are required to entail an EIA and this must be submitted to the Environmental Protection Agency (EPA). The EIA for projects should be accepted before mining licenses are granted, as the National Environmental Policy (NEP) aims at a sound management of resources and the environment.

The EIA is an environmental permitting prerequisite and management tool for which all projects are screened and evaluated. The main purpose of EIA has been:

- To support the goals of environmental management and sustainable development.
- To integrate environmental and economic decisions at the earliest stage of planning and undertaking.

- To predict the consequences of a proposed activity from the social, economic, cultural and environmental perspective and to develop plans to mitigate any adverse effects.
- To provide avenues for involvement of the public in assessment and review of the proposed activity.

The EIA of every project is supposed to go through the process to ascertain its ability to maintain the environment. The first process of an EIA is registration of the project and screening. It is expected that every project that will have an impact on the environment must of necessity register with EPA, so that a decision is made as to whether there is an objection or not to the undertaking for which a preliminary Entry Impact Statement (EIS) would be required.

Upon an indication of sufficient adverse land degradation from the operation when undertaken, the proponent will need to submit EIS for thorough evaluation involving interested and affected parties to determine how their concerns will be addressed (UST/ IDRC, 1997: 23).

Public hearing follows after the scope of the project effects has been determined. For all projects that attract strong public concern over the activity, the EPA shall hold a public hearing related to the assessment and to seek their opinion. After a satisfactory hearing and grievances resolved, the EIS is finalized and submitted to the EPA for Provisional Entry Permit issued for a period of 18 months.

After a year of operation, an Environmental Management Plan (EMP) is to be submitted in every two years. The plan covers a 5-year period, a 2-year EAP and a 3-year rolling plan for the subsequent years (Ghana Mining Journal, 1996 and 1998). In addition, companies are supposed to present an Annual Environmental Report (AER) to the EPA, also new mining companies shall submit EMP as part of an EIA.

3.4.2: FINANCIAL PROVISIONS

As stated above, there was the need to revamp output of the mining sector by removing financial hindrances that were associated with the mining sector in particular, in addition to the reforms in other related sectors and institutions. The Minerals and Mining Law (PNDCL 153) provided a line of action to reducing the financial burden on the sector. The financial provisions in the law included:

(a) Expenses on reconnaissance and prospecting may be allowed to be recovered after a commercial find and active operation.

(b) Machinery, equipment and other imported inputs for mining activities are exempted from customs and import duties.

(c) A royalty rate ranging from 3% to 12% for operating mines.

(d) The corporate tax rate was reduced to 35% from a high rate of 45%.

(e) Mining companies are allowed to retain a certain proportion of their export earnings in foreign accounts.

(f) A flexible exchange rate was implemented to secure funds for activities.

(g) A 75% of the cost of capital was allowed as depreciation with 50% in the subsequent years. In case of a loss, there is a provision of a carry forward of the depreciation allowance.

3.4.3: MINERAL POLICY AND LEGISLATION

The Minerals and Mining Law of 1986 represents the principal legislation that provides regulation concerning minerals and process of acquiring mining leases. The mineral policy in Ghana entails the following elements:

- The law vests all minerals in the State. The government is given the right to own all minerals in the nation. She has the pre-emption over all natural resources.
- The government is entitled to 10% share in all mining companies. In addition, there is the option to buy an additional 20% when need be and also at a reasonable price.
- Both local and foreign private companies have the right to participate or share in state owned mining companies.
- Establishment and promotion of minerals development and institutions responsible for this sectoral development. Such assistance includes data, maps and geological surveys.
- Providing technical support to small-scale miners.
- Instituting a system whereby output especially gold will attract realistic prices.
- Encouragements of investors, both local and foreign through incentives such as are provided in the mining financial provisions, external retention of export earnings, fading out of import duties and charges on mining equipment.

- ❖ The opening of the door to both Ghanaians and foreigners for minerals exploration and development without any partiality. Apart from these, other resources; sand, stone and gravel among others are reserved for only Ghanaians.

As stated above, the mineral policy of Ghana was promulgated to facilitate the smooth development of mineral resources of the country, by way of eradicating the difficulties that hindered the progress of this sector. In addition to these policy initiatives, there was a systematic legislative approach to acquire mining right for production.

After the enactment of a favourable mineral investment code in 1986, several investors have undertaken prospecting for minerals especially for gold. For smooth running of the policy to achieve its aims, proper legislation was to be laid down in acquiring mineral rights. Mineral rights are granted by the Minerals Commission and they entail the following:

1. A Reconnaissance License: The holder of this license is given the right to look and search for a specific mineral. This can be done using any of the following: geophysical, geochemical and photogeological methods. Such a license has a maximum of 12 months duration but is renewable if and only if this is in the interest of the public. Unless the license allows for it, there is no drilling, excavation or any activity on the land.
2. Prospecting License: This entitles the holder to prospect for a specific mineral, determine its extent and economic worth. The area allowed for such a license is

150 km^2 tenable for three years, but renewable for two years at a time. The renewal of the license reduces the area into half.

3. Mining Lease: Mining lease holders have the right to extract minerals. This license is granted for a period of 30 years for a maximum area of 50 km^2. If the same holder obtains more leases, the aggregate area of 150 km^2 is the maximum limit.

4. Restricted License and Lease: Such licenses are reserved for certain resources such as clay, sand, gravel, limestone, basalt and granite (Aboagye, 1998).

After the introduction of these procedures and other incentives in the mining sector, many investors both local and foreign have been attracted to this sector. This has caused large amounts of capital to be invested in mining activities especially gold mining.

3.5: GHANA'S LAND UNDER GOLD MINING

There is almost no end to the things human beings have done to make their land productive. Land and its properties as a free gift of nature and for that matter a resource to the human race should be viewed to reflect its natural values and physical properties as well as its capacity to satisfy individual wants. Again, land in itself has composite and derived values, and this is reflected in its multiple use, the aim of which is to maximize net public benefits.

Ghana is a country with diversity of natural resources despite her relatively small size. The land stretches 672 km from north to south and 536 km from east to west. The total

land area is estimated to be 238,534 km^2. The southern belt of the country, about two-thirds of which could be described as forest area is endowed with a lot of wealth including minerals, timber, game, flora and fauna and other resources that may not have direct commercial value.

3.5.1: DESCRIPTION OF THE COUNTRY'S VEGETATION

The location of the country falls within two broad ecological zones. These ecological zones include high forest and savannah zones. The usual vegetation of tropical climates, which include savannah and forest engross the entire country. An area of about 81,342 km^2 out of the total land area of 238,534 km^2 is made up of forest. This high forest area is confined to the south-western side of the country.

Table 3.2: Forest zones of Ghana

Type	Area (km^2)	Percentage (%)
West Evergreen	5,576	8.08
Moist-Evergreen	17,770	21.85
Moist-Evergreen-deciduous	32,890	40.43
Dry Semi-deciduous	21,440	26.36
Upland Evergreen	292	0.36
Southern Marginal	2,360	2.90
Southern-East Outliers	20	0.02
Total	**81,342**	**100**

Source: Forestry Services Division Annual Report 1995 (formally Forestry Department)

The rest of the country's land area broadly described as the savannah zone dominates the east and the north of the country. It covers an area of about 157,198 km^2. The Sudan savannah woodland occupies about 1,955 km^2 whereas the coastal thicket and grassland, and strand and mangrove also engross an area of about 4,507 and 1,277 km^2 respectively.

3.5.2: MULTIPLE LAND USE IN THE FOREST AREAS

The composite value of land varies from place to place depending on the identifiable available resources. The forestland, due to its abundant resources, is expected to be of higher value than the savannah zone.

The regions that contain the country's forests display practically every type of agriculture system from the old shifting cultivation to the modern huge plantation. As already stated, the agriculture systems run side-by-side mining and other land use activities such as logging.

Before the country declared her freedom from Great Britain in 1957, the economy of the colony was based predominantly on both agriculture and mining. However, in recent past decades, with new possibilities for production of gold in particular, the gold mining industry has overtaken the agriculture sector in terms of foreign exchange earnings. This expansion in gold mining industry has come about in response to the introduction of

surface mining involving the use of heavy-duty machines, which has led to increases in land coverage. The Forestry Department in its 1992 and 1996 annual reports classified forestland use in Ghana as shown in the table below.

Table 3.3: Land use of forest area in Ghana

Land use	**Area (km^2)**	**Percentage (%)**
Forest Reserve (Permanent Forest Estate)	16,788	20.64
Unreserved Forest (potential farmland & private commercial forest)	172	0.21
Other lands (cocoa, food farms and bush fallow)	64,382	79.15
Total	**81,342**	**100**

Source: Forestry Services Division Annual Report, 1992 and 1996

Apart from this classification, land use in these areas could be grouped into five categories. These categories are agriculture, mining, lumbering, protection reserves and settlements. Agriculture is found at all levels of the ecology of the south-western part. Various food and cash crops are produced especially cocoa.

Lumbering in the south-western part of Ghana is not an exceptional case. Almost every part of this forest zone is affected by activities of the timber operators. Some gold mining companies, if not all, also engage in the destruction of economic trees throughout their operations.

In terms of settlement, farmers and local land-owners all over the area establish villages, which bring them in close contact with their property.

The most outstanding land use activity in these regions is gold mining. Its position is not because it occupies a large proportion of the region's land but because it's one of the oldest practices and at the same time one of the most viable ventures in the region.

It is an obvious fact that, in all the regions of Ghana, there are mining concessions but only four of the regions have mining leases. These are Ashanti, Western, Eastern and Central Regions of which the dominant ones are Western and Ashanti Regions, which also contains the nation's forests. This can be seen in the table below.

Table 3.4: Total mineral concessions in Ghana (km^2)

Regions	Total size: G	Total size: F	Total size: ML	Grand total size of concessions
Western	3,085.52	6,933.79	998.27	11,017.58
Ashanti	3,075.61	1,790.06	1,027.36	5,893.03
Eastern	895.30	576.77	664.87	2,136.94
Central	1,238.64	543.22	242.18	2,024.04
Brong Ahafo	1,463.83	7,750.32	-	9,214.15
Northern	532.55	3,326.61	-	3,859.16
Upper East	-	362	-	362
Upper West	-	3,160.33	-	3,160.33
Volta	41.12	-	-	41.12
Total	**10,332.57**	**24,443.1**	**2,932.68**	**37,708.35**

Source: Minerals Commission

From Table 3.4 above:

ML represents: Mining Leases

G represents: Ghanaian Controlled Exploration Companies

F represents: Foreign Controlled Exploration Companies

From the above table, out of a total of 37,708.35 km^2 of concessions in Ghana, 2,932.68 km^2 has been given mining leases which is about 7.8% of the total mining lease concessions in Ghana and 1.2% of the total Ghana land surface of 238,534.17 km^2 – out of this figure, 1,875.17 km^2 (64% of mining lease concessions) is under active operation.

3.6: INVESTMENT TREND IN MINING

Ghana had since 1983 attracted a number of foreign investment; foreign direct investment, multinational investment and partnership with Ghana mining industry, and these have come from all over the world.

Majority of the 12 gold producing firms registered with the Ghana Chamber of Mines as at March 2002, are foreign owned with their headquarters' in South Africa, Canada, United States of America and Australia. The investment trend of South Africa in Ghana's gold mining and total investment trend in the mining sector are given below:

Table 3.5: South Africa Investment in Ghana's Gold Mining (Mil US $) (1993 -1997)

ompany	1993	1994	1995	1996	1997	Total
nglo Mining (Gh) Ltd.				181,958	38,247	220,203
nmercosa Exploration		76,750	692,750	1,831,250	1,662,500	4,263,250
old Fields Ltd	1,000,000			19,715,520	105,102,460	125,817,980
I Ghana Ltd		240,208	432,910	1,161,480	1,818,746	3,617,344
onsu Gold Holdings		701,738	2,781,517	679,326	1,681,802	5,844,383
buom Goldfields				9,865	67,152	77,018
entenary Gold Mining		467,855	1,152,330	3,671,019		
rand Total	1,000,000	1,450,551	5,059,507	27,250,417	110,370,907	145,131,382

Source: Minerals Commission

Table 3.6: Investment Inflow into the Mining Sector (Mil US $) (1983 – 2000)

Year	Mining Companies	Prospecting Companies
1983	6.0	-
1984	58.04	-
1985	175.02	-
1986	-	-
1987	6.90	-
1988	-	-
1989	205.23	-
1990	268.52	129.72
1991	87.23	192.08
1992	421.30	174.10
1993	6.75	257.13
1994	10.07	88.25
1995	23.96	140.99
1996	79.77	694.99
1997	218.23	322.03
1998	172.78	63.24
1999	153.83	24.19
2000	29.09	179.40
Total	**1,922.72**	**2,266.12**

Source: Minerals Commission

As a result of these initiatives, many new mining companies have been brought into operation whilst others are in the process of starting. All these companies are using the Open Pit or Open Cast method of mining. The first gold pour of some new companies that came into the limelight after the new ERP initiative can be seen from Table 3.7 below.

Table 3.7: Some New Gold Mining Companies and First Gold Pour

Company	First Gold Pour	Mode of Mining
Resolute Amansie Ltd.	May, 1997	Open Pit
Abosso Goldfields Ltd.	November, 1997	Open Pit
Satellite Goldfields Ltd.	January, 1999	Open Pit
Goldfields Ghana Ltd.	January, 1999	Open Pit
Ashanti Goldfields Bibiani Ltd.	February, 1997	Open Pit

Source: Adapted from Salami and Tsekpo, 2000

The massive investments have been in the form of new exploration to active operation, rehabilitation of old and obsolete plants and privatization and divestiture of public mines. This process was aimed at increasing total output in the sector, of which gold has received the bulk of the fund. All the above initiatives have impacted on gold mining and export positively.

3.7: IMPACT OF ERP ON MINING

There have been positive results since the policies of the ERP were pursued in the mining sector for all the major minerals. The mining sector has been revamped from its downward decline. The production figures and index numbers for gold have been on ascendancy as shown in Table 3.8 below. The highest growth of 35.7% in gold production in 1998 occurred partly due to the high investment that has taken place in this area. Gold production has seen a continual increase after 1983.

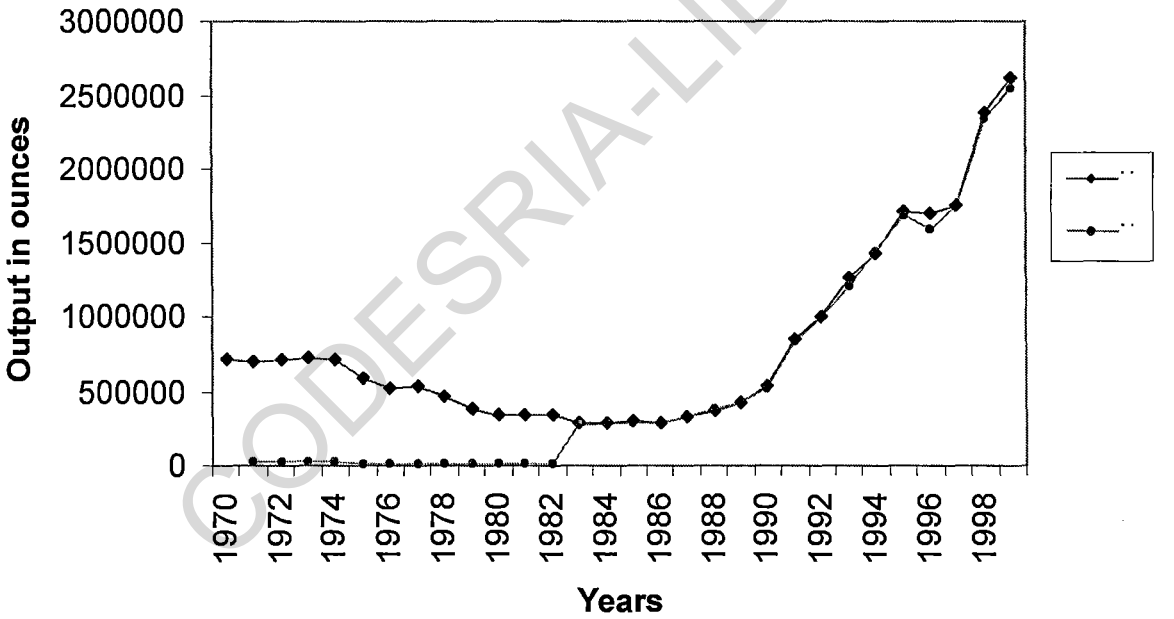
Total 3.8: Production Figures for Major Minerals (1970 – 2000)

Year	Gold (Fine ounce)	Diamond (Carats)	Bauxite (MT)	Manganese (MT)
1970	714,442	2,549,500	259,993	354,726
1971	693,770	2,561,000	361,038	455,253
1972	710,013	2,658,800	356,479	476,690
1973	731,711	2,306,800	330,351	533,789
1974	709,550	2,571,700	327,627	255,393
1975	583,103	2,336,200	383,087	282,291
1976	515,654	2,282,900	282,084	384,162
1977	531,084	1,946,800	271,090	343,228
1978	465,651	1,422,800	271,448	321,443
1979	387,730	1,225.600	331,782	342,051
1980	342,904	1,150,042	196,892	240,006
1981	338,042	836,491	156,769	197,439
1982	337,754	683,585	92,954	132,232
1983	285,291	338,771	82,310	175,288
1984	282,299	345,675	44,169	267,996
1985	299,615	636,127	124,453	357,270
1986	287,124	560,538	226,461	262,900
1987	327,960	440,681	201,483	242,410
1988	372,851	259,358	299,939	284,911
1989	428,936	285,636	374,646	273,993
1990	534,630	636,503	368,659	246,869
1991	847,560	687,736	324,313	311,824
1992	999,950	656,421	399,155	276,019
1993	1,257,489	590,842	364,641	295,296
1994	1,428,011	757,991	451,802	238,429

1995	1,717,654	631,708	530,389	186,901
1996	1,597,575	714,738	383,370	266,440
1997	1,755,240	829,524	536,723	332,443
1998	2,382,339	805,742	341,121	384,173
1999	2,620,121	684,033	355,263	611,500
2000	-	878,011	503825	859,596

Source: Minerals Commission, Chamber of Mines Annual Report 1995 and Ghana Statistical Service

Figure 3.2: Gold Production and Export Trend in Ghana - (Mil Oz) (1970-2000)



Key: GP is volume of gold production

GE is volume of gold exports

Diamond production has seen ups and downs for some time. In 1980, about 1,150,042 carats were produced but even after the ERP, this fell to 590,842 carats in 1993. The fluctuating growth in diamond production might be due to the fact that there is only one major company in Ghana – Ghana Consolidated Diamond Limited (GCDL), undertaking diamond extraction with a few small-scale miners.

Figure 3.3: Diamond Production Trend in Ghana (Mil Carats) (1970 - 2000)

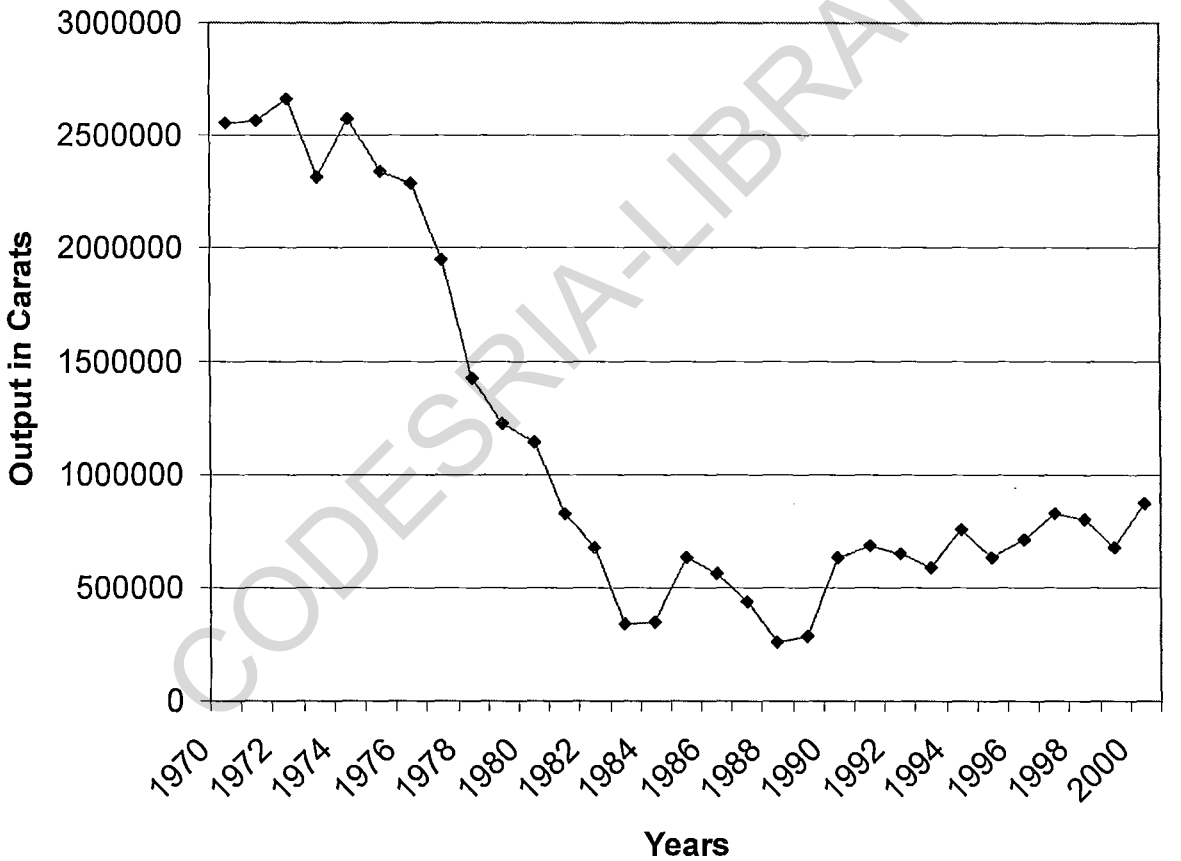
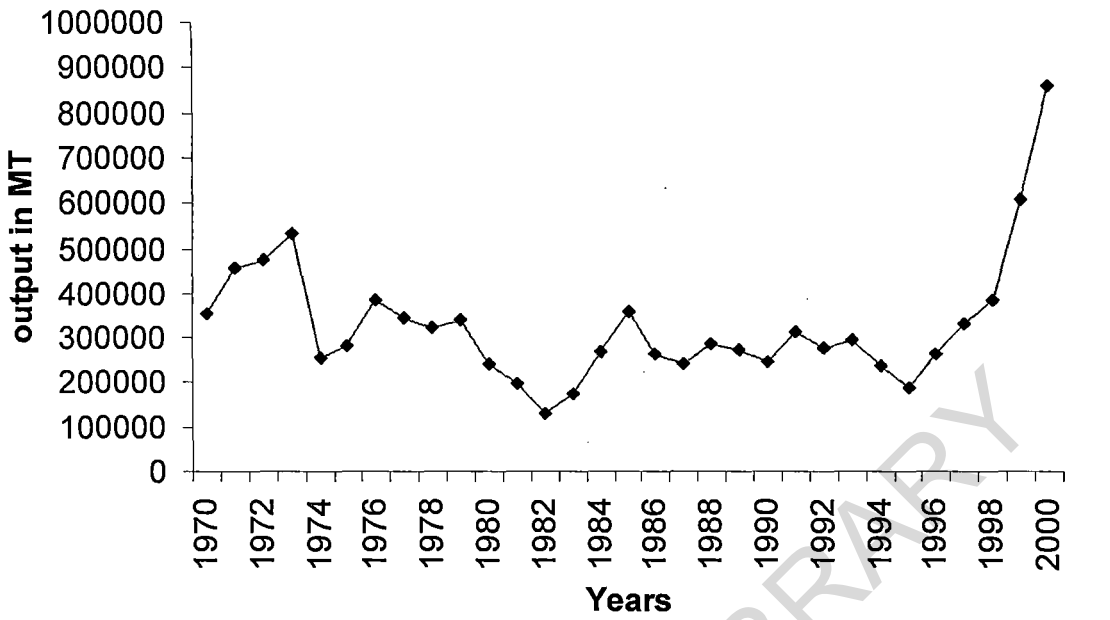
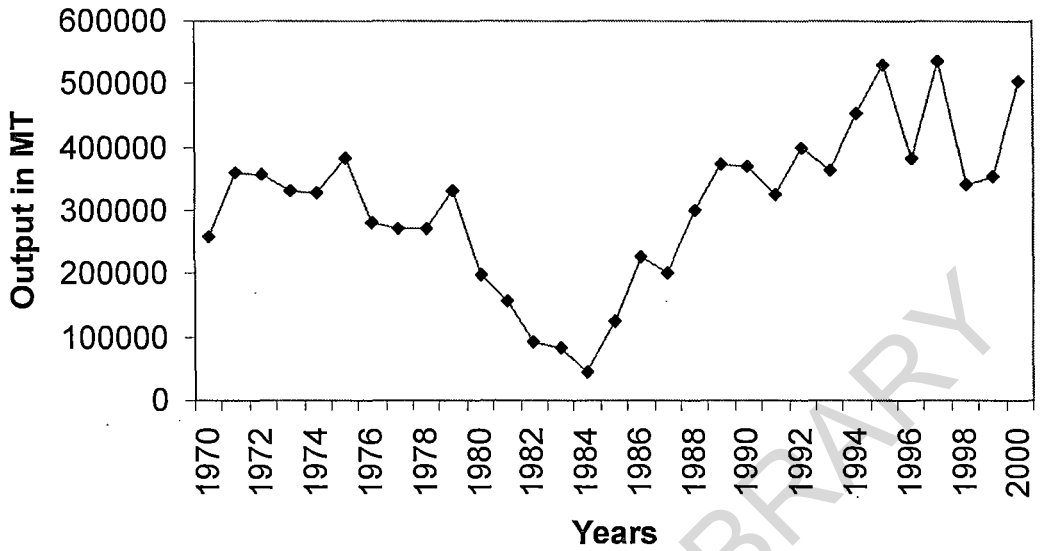


Figure 3.4: Manganese Production Trend in Ghana (Mil MT) (1970 - 2000)



The output figures of manganese have been increasing steadily even though they fell to their lowest level in 1995 with that being the lowest in the 1990s. Of all the minerals, bauxite has seen the worst improvement in production. The highest recorded output has been 536,723 in 1997 metric tonnes since the new policy initiatives were implemented.

Figure 3.5: Bauxite Production Trend in Ghana ('000 MT) (1970 - 2000)



Gold is now the major foreign exchange earner for Ghana, it accounted for US $ 710.82 million out of the US $ 2,005.5 million total export earnings for the year 1999, which was about 35.4%.

Table 3.9: Minerals Export Earnings (Mil US $) (1983 - 2000)

Years	Total Exports	Gold exports	Gold share in Exports (%)	Mineral exports	Gold share in minerals (%)
1983	439.28	114.09	29.97	121.68	93.76
1984	565.50	103.27	18.26	115.3	89.56
1985	632.48	90.62	14.32	107.9	83.98
1986	749.30	106.39	14.19	124.4	85.52
1987	826.63	142.34	17.21	159.28	89.36
1988	880.97	168.52	19.12	187.69	89.78
1989	808.20	159.93	19.78	186	85.98
1990	896.76	201.65	22.48	242.4	83.18
1991	997.68	304.44	30.51	351.9	86.51
1992	986.30	343.41	34.81	388.6	88.37
1993	1,063.64	433.95	40.79	473.5	91.64
1994	1,237.73	548.62	44.32	588.2	93.27
1995	1,431.19	647.27	45.22	678.8	95.35
1996	1,570.07	612.36	39.0	641.3	95.48
1997	1,489.87	579.21	38.87	613	94.32
1998	2,090.8	687.76	32.89	717.8	95.81
1999	2,005.5	710.82	35.44	749.11	94.88
2000	1,936.3	702.03	36.25	755.5	92.92

Source: Bank of Ghana and Writer's calculations

Table 3.10: Unit Price of Minerals (Mil US $) (1983 – 2000)

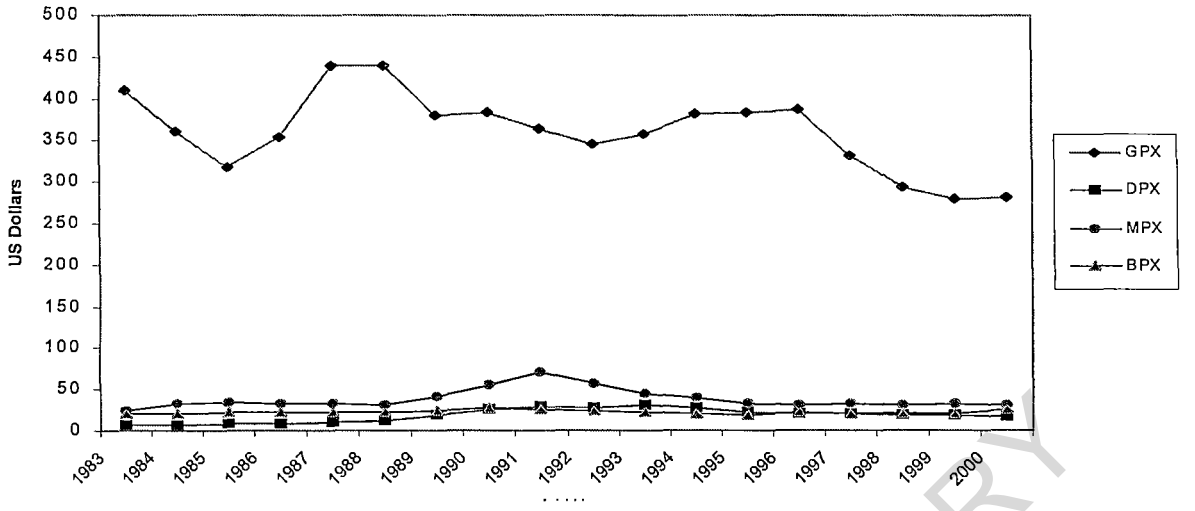
Year	Gold (US $/oz)	Diamond (US $/carat)	Manganese (US $/tonne)	Bauxite (US $/tonne)
1983	410.4	6.4	24.4	20.5
1984	361.4	6.6	33.5	20.5
1985	317.8	8.6	34.3	22.0
1986	354.1	8.5	33.4	22.1
1987	440.0	10.0	33.0	23.0
1988	440.0	11.5	31.0	23.0
1989	380.7	19.9	41.1	24.4
1990	383.1	26.0	55.7	27.0
1991	364.6	29.0	72.0	26.8
1992	345.0	28.0	57.7	23.9
1993	358.5	31.2	44.8	23.1
1994	382.2	28.4	39.1	21.2
1995	383.1	22.9	32.9	19.7
1996	386.5	21.2	31.1	22.0
1997	331.5	20.2	32.5	20.1
1998	293.1	19.1	32.1	21.6
1999	278.7	18.4	33.1	21.5
2000	280.4 *	17.7 *	31.2 *	26.0 *

Figures with * are provisional

Source: Bank of Ghana

From Table 3.9, it can be seen that the export of minerals is concentrated in gold as it bears the larger part of export earnings. The trends of world prices of minerals are presented in Figure 3.6 below.

Figure 3.6: Unit Prices of Major Minerals (1983-2000)



Key:

GPX - gold price

DPX - diamond price

MPX - manganese price

BPX - bauxite price

There is no doubt that the increase in production and export of these minerals especially gold has contributed immensely to the development of Ghana. The export earnings of Ghana show that the bulk of the earnings come through the sale of minerals of which the prominent is gold as shown in Table 3.9 above. Available figures combine mining and quarrying together but evidence shows that the mineral sub-sector contributes the lion's share in export earnings of the economy.

Table 3.11: Production Performance of the Mining Sector (%) (1981 – 2001)

Year	Mining and Quarrying growth rate	Mining and Quarrying share in real GDP
1981	-8.45	1.0
1982	-7.9	1.2
1983	-14.36	1.1
1984	13.49	1.1
1985	6.45	1.2
1986	-3.03	1.1
1987	7.89	1.1
1988	17.84	1.2
1989	9.96	1.3
1990	6.35	1.3
1991	6.75	1.3
1992	10.36	1.4
1993	9.11	1.5
1994	5.08	1.5
1995	5.50	1.5
1996	4.20	1.5
1997	5.6	1.6
1998	4	1.6
1999	3	1.6
2000	1.5	-
2001	-1.6	-

Source: State of the Ghanaian Economy-ISSER; various issues

The mining sector has been a major revenue earner for the economy through the payment of corporate taxes, royalties, income taxes on salaries of employees and dividends declared. The contribution for a number of years has been tabulated below. It is seen that the total revenue from the mineral sector to total revenue for the nation continues to improve. There was an increase from ¢48.6 billion in 1995 to ¢189.3 billion in 2000 representing about 289.5% growth (Table 3.12).

Table 3.12: Contribution of Mining to Government Revenue (bil ¢) (1989 – 2001)

Year	Income Tax (mining)	Mineral Royalties	Total from Mining	Total IRS Collection	Mining Income over total IRS collection (%)
1989	2.075	1.208	3.282	-	-
1990	2.825	1.893	4.719	52.818	8.94 %
1991	0.821	3.021	3.843	61.485	6.25 %
1992	4.555	4.545	9.100	74.731	12.18 %
1993	4.310	7.485	14.460	113.236	12.77 %
1994	6.942	12.783	24.536	166.595	14.73 %
1995	19.713	20.911	48.610	275.513	17.64 %
1996	2.879	35.492	56.458	424.491	13.30 %
1997	14.094	32.696	80.181	605.782	13.24 %
1998	4.060	49.484	84.562	785.436	10.77 %
1999	8.528	48.620	84.988	901.663	9.43 %
2000	11.404	118.736	189.385	1,409.445	13.44 %
2001*	24.676	127.368	234.641	1,950.162	12.03 %
Total	**106.887**	**464.249**	**838.771**	**6,821.364**	**12.06 %**

Source: Minerals Commission

IRS is Internal Revenue Service
* Provisional figures

The nation earns a lot of foreign exchange from the export of minerals. The mining industry has since 1992 become the first foreign exchange earner, having beaten cocoa to the second position. An amount of US $ 710.82 million was earned in 1999 from gold export, which was 95% of a total of US $ 749.11 million obtained through mineral export in that year.

Another area in which mining sector as a whole has impacted and benefited the nation is the employment sector. Estimated figures of employment for the total industry have been given below in Table 3.13. The employment peaked at 25,637 in 1996 but reduced to

20,269 in 1999. This might be due to the fact that the existing underground mining has been substituted with surface mining (Open cast), which is highly mechanized unlike the former, which needs more labour force.

It is estimated by Salami and Tsekpo (2000) that more than 7 percent of the labour force in the country is employed by the large-scale mining sector. Even though the number in the mining sector is not known with certainty, it is approximately put at 40,000 though this figure could be higher (Salami and Tsekpo, 2000).

Table 3.13: Total Employment in the Mining Sector (1990 – 1999)

Year	Total employment
1990	13,654
1991	16,470
1992	17,873
1993	20,186
1994	21,840
1995	24,299
1996	25,637
1997	23,465
1998	24,239
1999	20,269

Source: Adapted from Salami and Tsekpo

In the Minerals Development Fund policy, a fund consisting of 20% of total royalties paid from mining activities is used for general development projects, for addressing some of the negative effects mining environs suffer and to fund parts of the budget of the sector institutions. From 1993 to 1996, an amount of about 7.4 billion cedis has been paid to the mining communities for development (Adadey, 1997). In addition to financial support,

the local communities benefit in the form of building materials such as cement, roofing sheets and wooden boards for the local projects undertaken in the areas where mining activities take place. Some of these funds go to health, education, water and road repairs. In cases where resettlement is involved, the communities get new replacement for such facilities like drinking water, roads, houses and other infrastructures.

The distribution of the Mineral Development Fund has been broken down as follows:

- The District Assembly - 6%
- Traditional Council - 2%
- Stools in areas of mining operation - 2%
- Support for budget of sector institutions - 10%

Table 3.14: Disbursement of Minerals Development Fund – (bil ¢)

(1993 – 1996)

Year	District Assembly	Traditional Council	Stool Land
1993	0.416	0.138	0.138
1994	0.785	0.261	0.261
1994	1.237	0.412	0.412
1996	2.027	0.650	0.648
TOTAL	4.511	1.463	1.461

Source: Adapted from UST/IDRC 1997: 15

The mining industry also produces some of the raw materials for many minerals based domestic industries. These include manganese that is used for batteries, salt for pharmaceuticals products, kaolin for the manufacture of local powder, mica for ceramic industry, gold for the local gold smith and bauxite for the production of beads. Their supplies save the nation a lot of foreign exchange that would have been used to import them to sustain these local industries.

Mining communities are centres of brisk business. The infusion of incomes and purchases of mineworkers has a multiple effect even though this effect is dependent on the level of investment, employment, consumption and incomes of the parties involved. This suggests that the larger the magnitude of these parameters, the greater the benefits to the economy. These indirect activities include; cooked food sellers, foodstuff sellers, carpenters, masons, and 'second hand' clothes sellers among others.

CHAPTER FOUR

METHODOLOGY AND DATA ANALYSES

4.1: INTRODUCTION

In this section, emphasis has been laid on the methodology for the study, specification of the model and empirical analyses of the data to ascertain their relative significance in contributing to forest loss in Ghana. These have been done using multiple regression analyses.

4.2: METHODOLOGY

The methodology for the study is a combination of econometric (regression analyses), descriptive statistics, tabular and graphical representation followed by the required and necessary analyses.

In the regression analyses, forest depletion with particular reference to gold exports employs the Ordinary Least Squares (OLS) to estimate the model. In addition, other techniques of regression were used on the time series data such as Unit Root and Cointegration was undertaken to ascertain the stationarity of the time series data for the period 1970 to 1997.

4.3: MODEL FOR REGRESSION

In this section, following the literature review (economic theory on forest depletion); Barbier *et el.* (1988), Pearce (1991), Tufuor (1997), Oteng-Yeboah (1997), Anderson (1987), Gillis *et el.* (1988), Rowe *et el.* (1992), Myers (1992), Dzigbodi-Adjuma (1996) and Asamoah (1997), the explanatory variables of forest depletion (F) have always been urbanization (U), population growth (P), lumbering (T), mining (G), bush fires (B), charcoal burning (C), chain saw operations (O) and agricultural clearance (A). These variables have been used to explain forest depletion in Ghana.

This is an exact relationship, because it implies that forest depletion is completely determined by the above factors. That is, no other factor except those explicitly mentioned influences forest depletion. In mathematical economics, we express the economic relationship of forest depletion as:

$$F = f(U, P, T, G, B, C, O, A) \qquad (1)$$

This is the functional form of formulation.

In mathematical form:

$$F = \beta_1 + \beta_2 U + \beta_3 P + \beta_4 T + \beta_5 G + \beta_6 B + \beta_7 C + \beta_8 O + \beta_9 A \qquad (2)$$

The above forest depletion model is exact, since it presupposes that the only determinants of forest depletion are those that appear in the right hand side of the equation. Forest depletion will change only if some of those factors change. Thus, no other factor may have any effect on forest depletion. Yet it is common knowledge that in economic life, many more factors may effect forest depletion.

In econometrics, the influences of these 'other' factors is taken into consideration by the introduction into the economic relationship of a random variable (error term – *e*) with specific characteristics such as normal distribution, variance is constant in each period and the error term is independent of the explanatory variable(s).

Examples of factors that contribute to forest depletion but are not included in the model, which are catered for by the error term (*e*) are climatic changes, soil profile and composition, world market prices of gold and timber, afforestation, topography of the area, foreign demand for forest products, domestic price and demand conditions of timber and gold and GNP growth (per capita output).

Again, even if we include all the relevant variables in determining forest depletion, there will be some "intrinsic" randomness that is bound to occur that cannot be explained, no matter hard we try (Gujarati, 1992). The error term may also represent errors of measurement, such as rounding to the nearest digit.

Also, the "principle of Occan's razor" – that is descriptions be kept as simple as possible until proved inadequate. Other factors may affect forest depletion, but their combined influence may be so small and nonsystematic that one can incorporate it in the random term, *e*.

Thus, the model becomes:

$$F = \beta_1 + \beta_2 U + \beta_3 P + \beta_4 T + \beta_5 G + \beta_6 B + \beta_7 C + \beta_8 O + \beta_9 A + e \qquad (3)$$

Due to certain consideration, expressed in the sub-sections 4.4.2, the explanatory variables that have been used are gold exports, timber and timber products exports and population to explain forest depletion in Ghana from 1970 to 1997.

The new forest depletion model becomes:

$$F = \beta_1 + \beta_2 G + \beta_3 T + \beta_4 P + e \qquad (4)$$

linearising equation (4) by applying natural logarithm to it gives

$$\ln F_t = \beta_1 + \beta_2 \ln G_t + \beta_3 \ln T_t + \beta_4 \ln P_t + \varepsilon_t \qquad (5)$$

Where:

F = Forest area as a proxy for total forest depletion (in square kilometers - km^2)

G = Total volume of gold exports (in fine ounces – Oz)

T = Total volume of timber and timber products export (in cubic metres - m^3)

P = Total Ghanaian population (in millions)

ln = Natural logarithm

t = Time

β_1 = The intercept or constant term

β_2, β_3 and β_4 = The Coefficients

ε = Stochastic error term

We note that, the specification of the model depends on the complexity of the phenomenon being studied, the purpose of the study for which the model is estimated (forecasting, or obtaining accurate individual values for particular coefficients), the availability of data and the computational facilities available to the researcher (Koutsoyiannis, 1977).

Equation 5 is an example of a linear regression model. In linear regression analysis, our concern is to explain the behaviour of one variable (dependent – in our study, forest depletion) in relation to the behaviour of another variable(s) (independent – here in our study, gold exports, timber and timber products exports and population) allowing for the fact that the relationship between the two sides is not exact because of the presence of other factors included in the error term, *e*.

Since the equation is in log form, the coefficients may be interpreted as elasticities. It is expected that gold and timber exports will have a negative effect on the forest of Ghana in terms of depletion (that is, increases in their export volume increases forest depletion) while population may be positive or negative.

It has been common practice to refer to the structure of time series in terms of their order in integration. Time series data reflect a number of concerns, they are based on the assumption of asymptotic convergence suggesting that they are stationary. The essence of the problem lies with the presence of spurious regression, which arises, when the

regression of non-stationary series, which are known to be unrelated, indicate that the series are correlated (Adam, 1992 and Ndung'u, 2001).

4.4: DATA ANALYSES

4.4.1: DATA SOURCES

The study utilizes annual time series data for the period 1970 to 1997. Data for the study was obtained from both domestic and international sources and they are secondary. These secondary data were obtained from institutions that are directly involved in the extraction, processing and governing of the natural resource under consideration. They include: Minerals Commission, Ghana Chamber of Mines, Ministry of Trade and Industry, Ghana Export Promotion Council, Mines Department, Forestry Commission, Forestry Services Division, Ghana Statistical Service, Institute of Statistical, Social and Economic Research, Bank of Ghana Annual Reports, University Libraries and other research institutions, International Monetary Statistics (IFS) and World Tables.

4.4.2: DATA TYPE

Due to differences in the aims of collecting data by the responsible institutions, some of the data acquired from the above sources underwent some computations so as to put them in specific form that is consistent with the type and nature of the variables in the model to be estimated. These served as proxies for the particular variables in question. Due to time series data acquisition problems on forest depletion in Ghana, the level of total forest estate in each year was used as a proxy for forest depletion in the country.

On the part of gold exports and its effects on forest depletion, the total volume of fine ounces exported was used instead of the earnings from export or the total production level. This is due to the fact that, the unit price of gold keeps changing as demand and supply conditions in the world market vary (Table 3.10). Also, there is little difference between ounces produced and ounces exported (Figure 3.2).

The reason for using gold to represent all other minerals export in Ghana – manganese, diamond and bauxite is that each has only one major mining company in the country – Ghana Manganese Company Limited, Ghana Consolidated Diamonds Limited and Ghana Bauxite Company Limited. Also, gold forms more than 90% of the mineral exports earnings (see Table 3.9). Moreover, gold is the most widely mined mineral and has seen massive investment and expansion, and so far, it has about 14 operating companies.

Another variable is timber, due to the ban on logs exports in 1996, the total volume of timber and timber products exported were used rather than the log exports or the earnings. The use of the volume of export products of timber is advantageous because the price per cubic metre keeps changing due to the market conditions on the world market as pertains to gold.

Another reason for the use of export volume of the products is that, an exhaustible and non-renewable natural resource such as gold is found and exploited in the forest regions of Ghana mainly in Ashanti, Western and Eastern Regions. As a matter of fact, there is currently only Ashanti Goldfields - Obuasi Mine and Prestea Sankofa Gold Mine that are

operating underground mining, the rest are using Open Cast (Surface Mining) method. As such, to increase gold production and export volume means using and devastating more land and these depletes more of Ghana's forest estate.

In Ghana, forest depletion is also caused by increases in human activities apart from the extraction of gold and timber. Charcoal burning, bush fires, urbanization (increases in settlement sizes and wood materials needed for such settlements) and agricultural clearance are other contributors to forest depletion. As stated, there is virtually a lack of time series data on urbanization, bush fires (caused by hunting and burning of farm lands), agricultural clearance. It is certain however, that these activities are done by residents of a nation for survival and thus the growth of humanity increases the need to undertake these activities. Hence population has been used as a proxy for these variables in the estimation because the increase in these activities is dependent on human goal of survival. The survival calls for road construction, building of houses, cultivation of food crops and hunting. Thus, having examined the determinants of forest depletion in Ghana, the appropriate model specification and estimation form should be sought for.

Thus, time series data first have to be checked on their stationary properties before regression analyses are applied on them. These processes utilize the systems of Unit Root and Cointegration Tests.

4.4.3: UNIT ROOT TEST

Recent empirical studies have taken a new turn by ascertaining the stationarity of variables, after which regression analyses are carried out. This has become necessary because of the breakdown of well-known economic relationships in the late 1970s. Not only did they systematically fail to predict outcomes, but also it became necessarily obvious that this predictive failure was so marked among time series models and data (Adam, 1992).

A stationary series is a data set that does not show any clear trend over time. The problem here is that when series are not stationary, they may seem to be closely related because they are drifting in the same direction over time, when in actual fact there may not be any relationship between or among them. This might then lead to spurious correlation and thus draw the wrong inferences from the data.

As argued by Enders (1995), a spurious regression is characterized by high explanatory power revealed by the multiple correlation coefficient (R^2) and the Durbin-Watson (DW) statistic reflecting autocorrelation residuals. A stochastic series is stationary if its probability distribution is unchanged over time, this implies that the series mean is constant and variance is finite. A stationary series has the tendency to return to the mean when plotted unlike non-stationary series that drift away from the mean value. It is said to be integrated of order zero, [I(0)], or is characterized by the absence of a unit root. Thus, a non-stationary series is integrated of order greater than zero.

The order of integration is formally determined using the Dickey and Fuller (DF) Unit Root Test. A series (X_t) is integrated of order *d* if it becomes stationary after differencing *d* times. Such a series is denoted as $X_t \sim I(d)$. Under this condition, a stationary series is an I(0) and non-stationary series especially the random walk is I(1). Also, it is possible for non-stationary series to be of order two or more, that is, first difference or growth rate of the series is non-stationary.

On the assumption of autocorrelation process of order one, AR (1), then,

$$X_t = \alpha X_{t-1} + e_t \quad (6)$$

where the error term (e_t) is assumed to be a white noise process with zero mean and constant variance, $\varepsilon_t \sim (0, \sigma^2_\varepsilon)$, ε_t is stochastic and X_t is an I(0) process. To transform equation (6), by subtracting X_{t-1} from both sides gives:

$$\Delta X_t = (\alpha - 1) X_{t-1} + e_t \quad (7)$$

$$\Delta X_t = \rho X_{t-1} + e_t \quad (8)$$

Where $\rho = (\alpha - 1)$

The DF test involves estimating the value of ρ and testing for its significance.

The hypotheses are specified as:

Ho (Null): $\rho = 0$ or $\alpha = 1$ (this means that the series is non-stationary, has a unit root and it contains a trend influence). This implies that X_{t-1} should not explain X_t.

H1 (alternative): $\rho < 0$ or $\alpha < 1$ (implying that the series is stationary and I(0). We are testing for the negativity of ρ.

There are about four different regressions that are used in performing the DF tests:

$$\Delta X_t = \rho X_{t-1} + e_t \quad (9)$$

DF 1: This is a pure random walk, meaning that it relies on history or has a strong memory. This can be used as an auxiliary unit root test.

$$\Delta X_t = \alpha_0 + \rho X_{t-1} + e_t \quad (10)$$

DF 2 : This is a random walk with drift

$$\Delta X_t = \alpha_0 + \rho X_{t-1} + \alpha_1 t + e_t \quad (11)$$

DF 3: Random walk, with drift and trend term

$$\Delta X_t = \alpha_0 + \rho X_{t-1} + \alpha_2 t + \alpha_2 \sum_{j=1}^{k} \beta_i \Delta X_{t-j} + e_t \quad (12)$$

ADF: Augmented DF Test

From equation (9), if $\Delta X_t = \varepsilon_t \sim iid\ (0, \sigma^2_\varepsilon)$, then it has a stationary process [$|\alpha| < 1$] of order zero, [I(0)]. This implies that, if it is integrated of order more than zero, then the variable is not stationary, where $|\alpha| \geq 1$. Non-stationary series have a variance, which is asymptotic infinite, and the series rarely crosses the mean in finite sample and innovation to the series is permanent (Adam, 1992 and Egwaikhide, 1999).

The DF tests are used to test for the size of coefficient of ρ in the equations. But the test statistic is not distributed as a standard '*t*'. Dickey and Fuller (1979) have tabulated the distribution or the test statistic, which varies depending on whether the model contains a constant or trend term.

The DF test assumes an AR (1) process which is a drawback, if is does not, then autocorrelation in the error term in the equation will be biased. In order to overcome such

a problem, the ADF test can be used [that is equation (12)]. The lag k is set so as to ensure that any existing autocorrelation in ΔX_t is absorbed and the error term is distributed as white noise. The Unit Root test for the variables in the equation (5) are given below:

Table 4.1: Unit Root test results for the model variables

VARIABLES	DF 1	DF 2	DF 3	ADF*	ORDER OF INTEGRATION
lnF	-1.0010	-1.6518	-1.6760	-2.5859	I (1)
lnG	1.0039	-0.4582	-2.3014	-2.3664	I(1)
lnT	-1.0759	-2.7610	-2.3711	-1.8579	I (1)
lnP	11.3293	3.8180	-3.6709	-1.8687	I (0)

The critical values (for the study's sample size of 28) for the DF 1, DF 2, DF 3 and the ADF at the 5% significant level are -1.95, -3.0, -3.60 and -3.60 respectively
* The lag length for the ADF was 1

The test (DF) uses the t – statistic of the coefficient of the lagged level of X_t (that is X_{t-1}) and the result obtained is compared with the critical t-value given in the Fuller (1979) distribution table. It may be relevant noting that the critical values for the rejection (or acceptance) of the null hypothesis are a function of the sample size and functional form [any of the equations (9) to (12)] of the models used for the test (Egweikhide, 1999).

The decision criteria is that if the critical value is greater than the test statistic in absolute terms, then we accept Ho, implying that the variable in question is non-stationary and has to be difference until it becomes stationary. From Table 4.1, except for the population variable (lnP), which is stationary at levels, the rest of the variables became stationary after first differencing.

4.4.4: COINTEGRATION

Variables in an econometric model may be non-stationary, and thus assuming they become stationary after first differencing, then one may be tempted to write and estimate the model by differencing each once. But this breaks down the theories. Such a model is a short-run response and by differencing we have removed the long-run response (Ndung'u, 2001).

Cointegration represents the tendency of a group of variables to drift together over time, in order words have a long run relationship. This confirms theory tying the variables together. In testing for cointegration, the DF tests are used, but here the test is applied to the residuals of the cointegrating regression.

In line with Engle-Granger, there is cointegration if $Y_t \sim I(1)$, $Z_t \sim I(1)$ (where Z_t is a set of explanatory variables) and the residual of the equation, $e_t = Y_t - \alpha_0 - \alpha_1 Z_t \sim I(0)$ is simply the linear difference of the I(1) series. Thus, if the residuals from the linear combination of non-stationary series are themselves stationary, I(0), then we can accept that the I(1) series are cointegrated (Adam, 1992). This provides the basis for validating the regression, since the variables are I(1). The inability to obtain cointegration presupposes the presence of spurious correlation and hence the invalidity of any conclusion drawn.

When it is known that the variables are cointegrated, the relationship between them can be referred to as long-run (LR). As such, any deviation from the LR cannot be permanent but will return to the equilibrium path after some time.

It is seen from Table 4.1 that the variables are integrated of different orders. The cointegration test was performed on the error term of the regression of level variables and found to be non-stationary, as such they are not cointegration. We then resort to the level variables for the regression (Ndung'u, 2001). This drawback of the variables means that the model has to be estimated using the level series and then applying diagnostic tests on the model such as stability of the variables, coefficient tests and residual tests.

Table 4.2: Regression results of the model (equation 5)

Dependent Variable: lnF
Method: Least Squares
Sample: 1970 1997
Included observations: 28

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	6.335110	1.248615	5.073711	0.0000
lnG	0.143900	0.062998	2.284204	0.0315
lnT	0.203667	0.071308	2.856168	0.0087
lnP	-2.068102	0.509644	-4.057936	0.0005
R-squared	0.700090	Mean dependent var		3.051095
Adjusted R-squared	0.662602	S.D. dependent var		0.409829
S.E. of regression	0.238053	Akaike info criterion		0.098918
Sum squared resid	1.360063	Schwarz criterion		0.289233
Log likelihood	2.615152	F-statistic		18.67471
Durbin-Watson stat	1.111121	Prob(F-statistic)		0.000002

The variables: lnF, lnG, lnT and lnP are the natural logarithm of level values as explained in section 4.3.

The results show that the explanatory variables (gold exports, timber and timber products exports and population) explain about 70% of the cause of forest depletion in Ghana for the sample period. This reveals a high explanatory power of the model.

The gold export variable has the expected sign (as been positively related to forest depletion). Its coefficient value of 0.1439 shows that for every one 1% change in the volume of gold, there will be about 14% change in forest depletion for the sample period.

Timber (and timber products) exports also has the expected sign; the increased export of these products will lead to a lost of forest estate, its coefficient seems to be higher than that of gold. A 1% change in total volume of timber and timber products exports will lead to about 20% change in forest depletion for the sample period.

The population variable gave a coefficient of –2.068, this means that, there is a negative relation between population and forest size of Ghana. In this situation, as population increases, forest size falls, but the fall in forest size implies that forest depletion is increasing. Therefore, there is a positive relation between population increases and forest depletion in Ghana for the sample period.

The coefficient of population means when there is a 1% change in population of Ghana, there will be about 20% change in forest depletion for the sample period. This results from influences such as increased demand for fuelwood, wood materials for housing purposes, agricultural land purposes, chain saw operations and charcoal burning.

The independent variables are all significant at the 5% level as revealed by the prob-value from the above table. That is, at this significant level, the prob-values are smaller comparatively. The significance of gold exports in causing forest depletion has economic implications in diverse ways.

4.5: ECONOMIC IMPLICATIONS OF RESULTS

These results show that as we exploit our gold deposits, although we obtain returns in the form of foreign exchange, income for employees and revenue to government, there is a direct effect of forest depletion. This forest depletion results in various indirect economic implications for the nation.

One of the economic implications is the subsequence cost of treating water related health problems. The watersheds of the people who dwell in the hinterlands are destroyed. They will depend on stagnant water and other bodies that are not wholesome because most of these areas do not have access to treated water. There will be an additional cost of maintaining the health of these people.

In addition, the forests are main sources of biodiversity and eco-tourism. When the forests are destroyed, there will be loss of revenue to government.

Again, since grassland sometimes replaces lost forest and degraded soil, there is the likelihood of climatic change, which will affect food production. The fall in food output as a result will have to be replaced by importing from other countries thereby reducing the amount of foreign exchange available for other developmental projects and importation of vital equipment. Aside these effects, the increase importation of food will worsen the balance of payments position of the nation.

Moreover, siltation of river courses, flooding and loss of wind breaks cause havoc to both human beings and property. Aside the health implications explained earlier, these cause houses to be destroyed, thus making many homeless. The government will have to provide shelter for the people at a cost.

The cost of refitting the forest also impacts on the economy. Cost of afforestation through tree seedlings acquisition, tree planting and maintenance will siphon resources from other productive sections of the economy.

4.6: DIAGNOSTIC TESTS

Various tests can be performed on the residuals of the regression. The test summary statistics of the model (equation 5) is given in the table below:

Table 4.3: Test summary statistics of equation 5

Test type	F – Value	Prob-Value	Significant level
AR 1- 2 F(2, 22)	2.2347	[0.1308]	
ARCH 1 F(1, 22)	21.752	[0.0001]	**
Normality Chi^2(2)	2.0289	0.3616]	
RESET F(1, 23)	4.326	0.0689]	

** The test is accepted at 1% significant level

The tests performed on the model indicate that there is no autocorrelation in the error terms even at the 1% significant level. On the other hand, there is Auto Regressive

Conditional Heteroskedasticity at the 1% significant level. The Normality test shows that the residuals are normally distributed indicating that they are white noise. Again, the RESET test shows stability of the coefficients.

Recursive estimates were done (Appendix D) and they show that the coefficients are stable except for 1983 where the long-run equilibrium changed slightly.

The Wald Coefficient Test was performed for gold exports, timber and timber products exports and population and the null hypotheses were rejected at 5% significant level. This implies that these variables are significant in causing forest depletion in Ghana for the sample period, and thus, the model specification form was correct.

Our estimated results indicate that population has a negative effect of forest of Ghana like other studies. For instance, in Hainen Island in China, Zhang, Uusivuori and Kuuluvainen (2000) estimated that population growth is a significant driving force behind the loss of natural forests. This suggests that growing population generally causes some rainforests to be converted into agricultural, industrial and residential land. In the same way, higher timber prices have accelerated rainforest exploitation. This study was based on panel data and generalized least squares estimation method from 1957 to 1985.

Barbier and Burgess (2001) estimated that agriculture development is significant factor determining land expansion but institutional factors have an important influence. Income effects tend to vary from region to region and do not always display an 'Environmental

Kuznets Curve' relationship. This study was based on panel analyses of tropical agricultural land expansion from 1961 to 1994 for selected countries from Africa, Latin America and Asia.

Another study by Pandy and Wheeler (2001) found that Structural Adjustment has had strong impacts on exports, consumption and production in many forest products sectors (fuelwood, sawnwood, panels, pulp and paper). It was noted that, the growth in roundwood production (which was used as a proxy for forest depletion) was well explained by growth in population, urbanization and world demand for forest products. This study was based on World Bank Structural Adjustment Loan (SAL) operations with 38-year socioeconomic database for 112 developing countries.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1: SUMMARY

In an attempt to determine the extent of gold mining for exports' contribution to forest depletion for the study period of 1970 to 1997, the importance of forest estates were presented as well as causes and effects of its depletion. In particular, the effects of gold mining methods have also been analyzed.

The increase in exports of gold was due to its abundant supply (in terms of its being found at different places in the country) and the export orientation strategy adopted.

The state of the Ghanaian economy before and after the ERP was presented. There was a general worsening of macroeconomic variables such as inflation, growth rates, balance of payments deficits and budget deficits before the ERP. After the programme, there was an improvement in these variables in the economy.

The trend in output of gold showed a decline in production until 1983 when the lowest figures were recorded. After the introduction of ERP, strategic incentives such as financial provisions, mineral policy and legislation and removal of mining licensing acquisition problems led to the recovery of production levels. This has made the mining sector the major foreign exchange earner for the nation today.

We estimated a linear regression model using Ordinary Least Squares (OLS) methods. This was based on the fact that gold extraction for exports (the focus of the study) combines with other factors to cause forest depletion. These other factors were replaced with their appropriate proxies and the results showed that gold exports contributed to forest depletion in Ghana for the study period.

5.2: POLICY RECOMMENDATIONS

In the light of the above findings from the study, we recommend that granting of mineral rights be tied to both afforestation and reafforestation schemes presented in the license seekers' environmental action plans, renewal of such licenses should be based on past record of adherence.

It is recommended that mining institutions and authorities begin to move from forest areas to non-forest areas in terms of granting mining leases.

Also, since gold could be mined underground as was done in the past, it is recommended that emphases should be placed on the need to return to the underground mining to maintain our forests.

Again, it is recognized that the trees in the mining lease concessions are not allowed to be cut by either local dwellers or timber operators. This would have prevented the people in those localities from entering into new forest areas. The mining operators destroy the trees without using them and at the same time buy from the market, which increases the need to cut down more timber.

Reclamation plans of all mining companies should be made mandatory at all levels of the activities of the mining companies.

The ban on log exports should be enforced and made to continue. This is because it will help slow down the rate of tree cutting and also improve upon the earnings from timber exports since the value added would be higher in this case.

The forestry sector institutions should make timber concessions law strict enough so that any breach of agreement attracts a financial penalty, withdrawal of such concessions or both.

Moreover, the activities of charcoal burners should be closely monitored so that they do not enter into protected areas or cut trees extensively at a particular place.

Family planning campaigns should be intensified in the forest localities to educate couples about the need for family planning to help reduce population pressure on the land. This can be done by showing films in the rural areas since the television adverts are

not within the reach of many rural dwellers. The inability to obtain a television set implies inability to hear and know the need to preserve our forests.

Finally, the government should make tree seedlings available to those who are ready to go into tree planting for livelihood and for the local people to plant in their localities. This can be done by using part of the revenue obtained from gold mining to help maintain the forest and refit the facilities that might be affected during the mining operations.

5.3: CONCLUSION

The fast rate at which the country's forest estates are being depleted calls for proper attention and that necessitated this study. This depletion of forest is caused by land use options that are of higher a rate than that of reafforestation and natural regeneration of the forests.

It is evident from the study that gold extraction for exports contributes to forest depletion in Ghana. It is hoped that the recommendation and conclusions arrived at will assist all economic agents and policy-makers to develop policies that will help preserve the nation's forests.

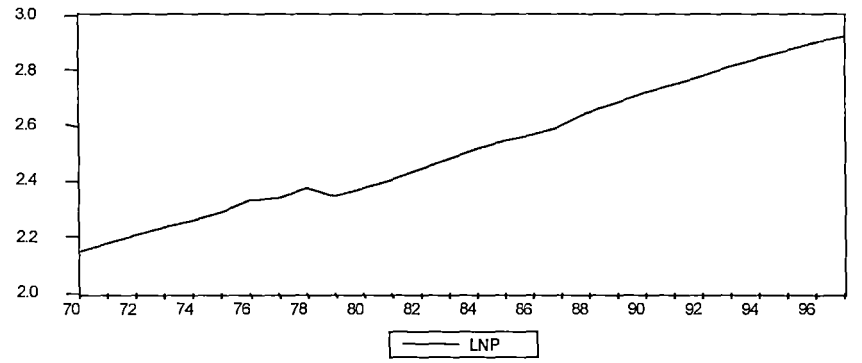
Again, the study is expected to add to existing knowledge on forest depletion and the contribution of gold extraction in Ghana.

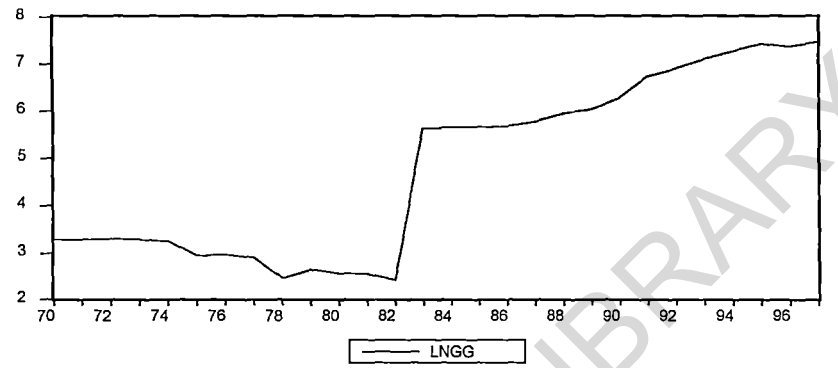
APPENDICES

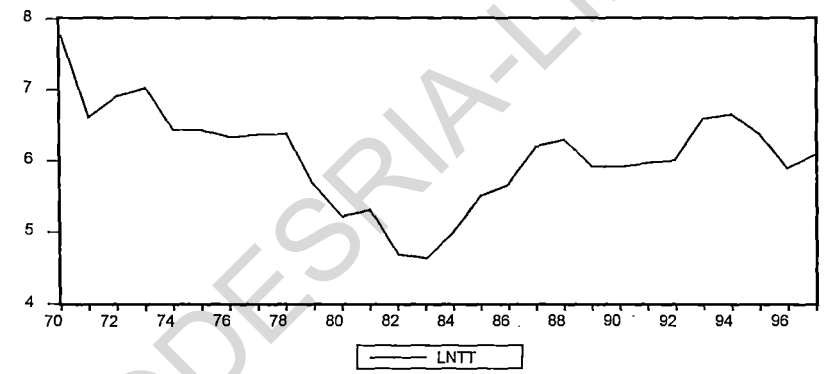
Appendix A: Values of variable used in the regression

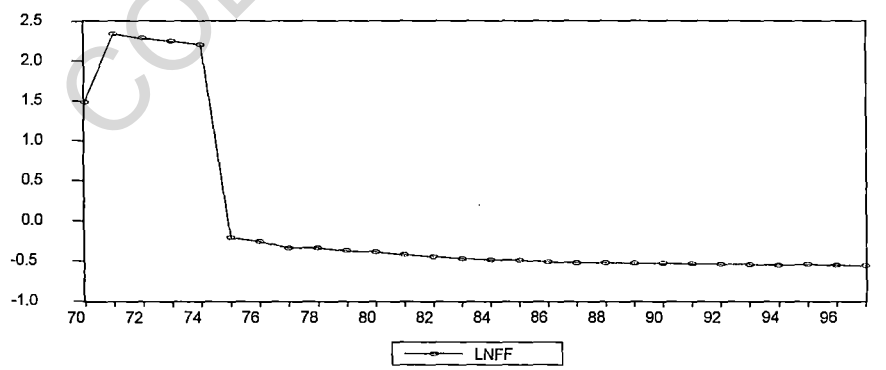
Year	lnF	lnG	lnT	lnP
1970	3.648422	3.291903	7.765145	2.152924
1971	3.994653	3.287506	6.616065	2.181547
1972	3.973438	3.313677	6.913737	2.207175
1973	3.95883	3.294243	7.033506	2.239645
1974	3.939424	3.256981	6.434547	2.262804
1975	2.967436	2.952929	6.434547	2.2895
1976	2.947697	2.980314	6.336826	2.333114
1977	2.915715	2.903891	6.37332	2.342767
1978	2.915606	2.459076	6.381816	2.374906
1979	2.901806	2.648866	5.652489	2.349469
1980	2.895912	2.563487	5.220356	2.374906
1981	2.883011	2.558389	5.31812	2.404239
1982	2.872773	2.421345	4.70048	2.439735
1983	2.863001	5.627621	4.637666	2.478218
1984	2.856125	5.655149	4.998914	2.51689
1985	2.85532	5.652973	5.508627	2.543176
1986	2.847	5.677476	5.674635	2.568788
1987	2.842056	5.779187	6.20161	2.594508
1988	2.841882	5.948017	6.302212	2.649008
1989	2.840306	6.040483	5.929126	2.685805
1990	2.838845	6.265987	5.913503	2.71668
1991	2.837674	6.727415	5.97533	2.747912
1992	2.835446	6.903122	6.007982	2.77944
1993	2.833801	7.098767	6.590044	2.811208
1994	2.835446	7.269209	6.659294	2.841415
1995	2.830976	7.43217	6.380123	2.870736
1996	2.830858	7.367948	5.89927	2.898671
1997	2.827314	7.465666	6.091348	2.926382

Appendix B: Graphs of the variables

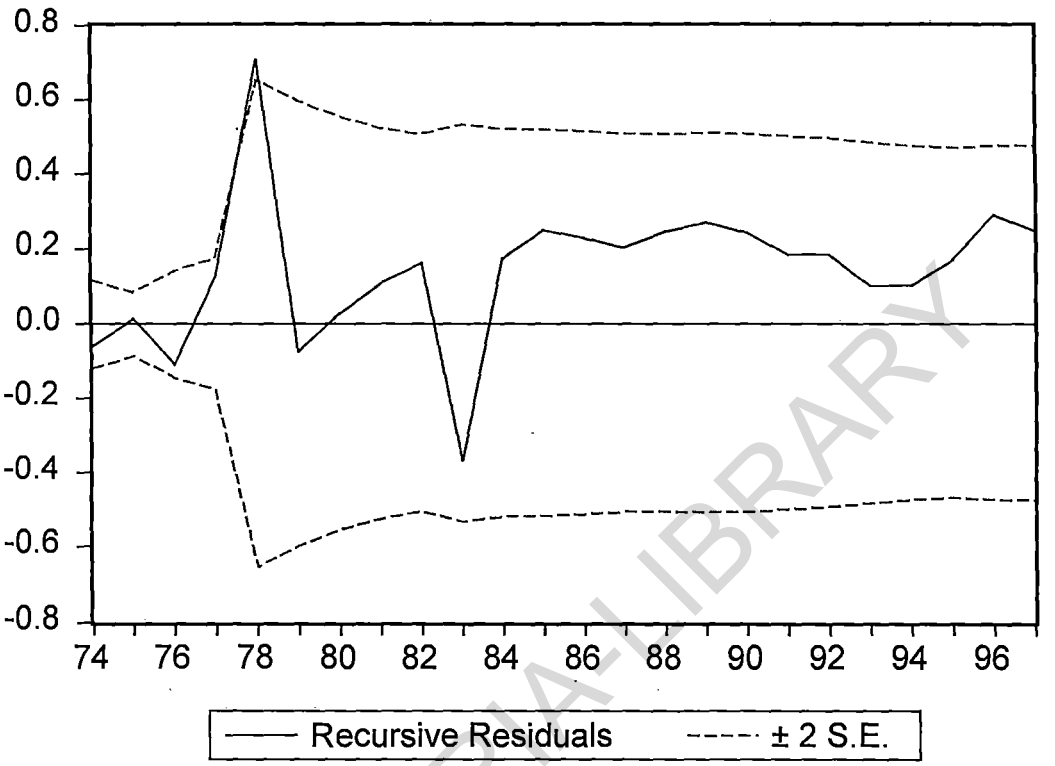




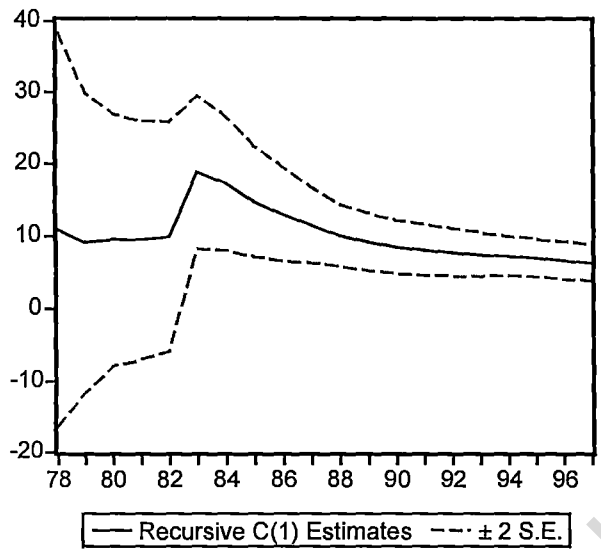


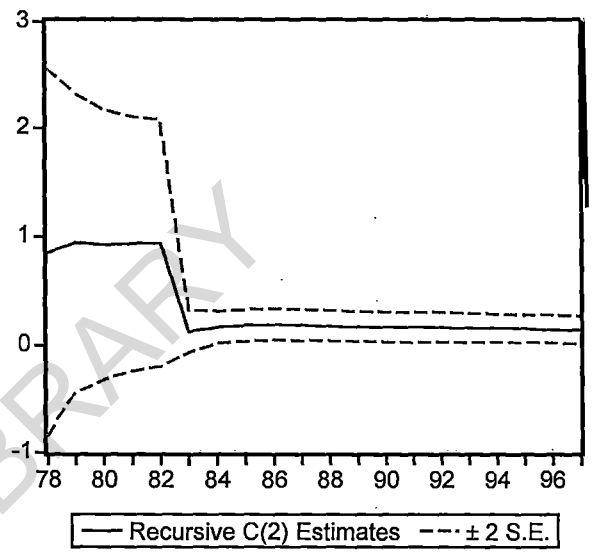


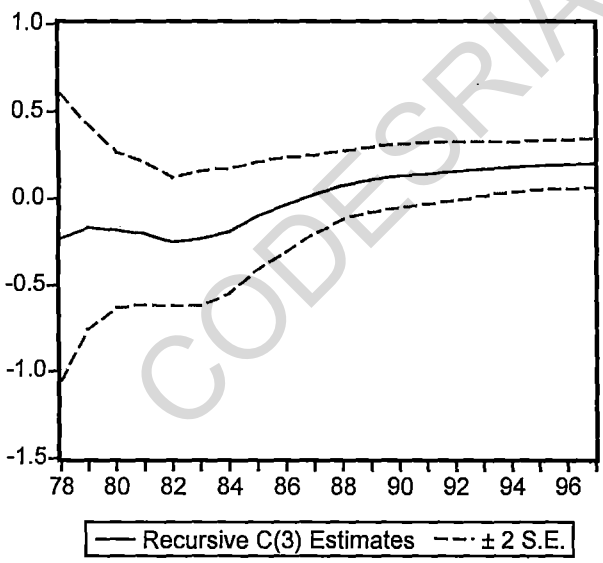
Appendix C: Recursive Residuals

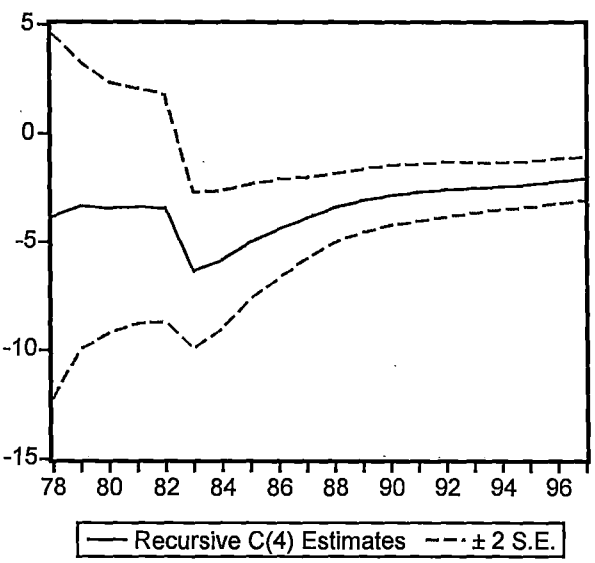


Appendix D: Recursive Coefficients









C(1) = ln F C(3) = ln T

C(2) = ln G C(4) = ln P

Appendix E: Wald Coefficient Tests

Wald Test:
Equation: 5

Null Hypothesis:	(lnG)=0		
F-statistic	5.217587	Probability	0.031500
Chi-square	5.217587	Probability	0.022360

Wald Test:
Equation: 5

Null Hypothesis:	(lnT)=0		
F-statistic	8.157696	Probability	0.008711
Chi-square	8.157696	Probability	0.004288

Wald Test:
Equation: 5

Null Hypothesis:	(lnP)=0		
F-statistic	16.46684	Probability	0.000455
Chi-square	16.46684	Probability	0.000050

Appendix F: Summary statistics of the Variables

	lnF	lnG	lnT	lnP
Mean	23.96007	546.2770	448.0481	3.051095
Median	17.45400	467.7800	281.5690	2.859563
Maximum	55.31400	2357.000	1747.018	3.994653
Minimum	16.90000	103.3030	11.26100	2.827314
Std. Dev.	13.96557	436.5721	578.8030	0.409829
Skewness	1.677291	2.655990	1.197680	1.711054
Kurtosis	3.839713	11.70581	2.988240	4.055434
Jarque-Bera	13.95139	121.3429	6.694198	14.96222
Probability	0.000934	0.000000	0.035186	0.000564
Observations	28	28	28	28

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